

LAKE COUNTY, IL

2014 SUMMARY REPORT DUNN'S LAKE

PREPARED BY THE
LAKE COUNTY HEALTH DEPARTMENT
POPULATION HEALTH-ECOLOGICAL SERVICES



Dunn's Lake, 2014

Dunn's Lake, is a 67.5 acre glacial lake located in northwestern Lake County, within the village of Fox Lake and part of the larger Fox Chain O'Lakes waterway system. Residents use Dunn's lake for boating, fishing and beaching. The main lake bottom ownership is privately owned in a trust. Vacation Village owns a marina and a channel that connects directly to the lake. Access to Dunn's Lake from the shoreline is private, however, since it is part of the Chain O'Lakes, public access is available from Nippersink Lake. Multiple homeowner have access to association piers or beaches for recreational use within the lake. The current maximum water depth of Dunn's Lake is 7.5 feet with an average water depth of 3.75 feet.

In 2014, the Lake County Health Department– Ecological Services (LCHD-ES) selected Dunn's Lake to be monitored along with 12 other lakes in the Fox Chain O'Lakes. Water samples were taken once a month at the deepest location in the lake from May to September (Figure 1). Due to the shallow nature of Dunn's Lake, water samples were only collected near the surface instead of multiple depths. The shallow depth means that Dunn's Lake does not thermally stratify. Rather than dividing into a warm upper water layer (epilimnion) and cool lower water layer (hypolimnion), Dunn's Lake instead stays well mixed throughout the ice free season. This report summarizes the water quality sampling, beach sampling, and the aquatic plant survey results on Dunn's Lake for 2014 conducted by LCHD-ES.

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LAKE FACTS

MAJOR WATERSHED:

FOX RIVER

SUB-WATERSHED:

UPPER FOX RIVER

SURFACE AREA:

68 ACRES

SHORELINE LENGTH:

3.87 MILES

MAXIMUM DEPTH:

7.5 FEET

AVERAGE DEPTH:

3.75 FEET

LAKE VOLUME:

254 ACRE-FEET

WATERSHED AREA:

455 ACRES

LAKE TYPE:

GLACIAL

CURRENT USES:

**FISHING, SWIMMING,
BOATING,
AESTHETICS****DUNN'S LAKE SUMMARY**

Dunn's Lake, along with the Fox Chain O'Lakes, is designated as public waters by the Illinois Department of Natural Resources. This means the Fox Chain O'Lakes are a navigable waterbody and open or dedicated to the public use. The area is one of the busiest inland recreational waterways per acre in the United States with weekend usage around 60,000 people, and up to 100,000 people on weekends. The Chain O'Lakes, and all navigable channels directly connected to these lakes, are under jurisdiction of the Fox Waterway Agency, a regional body of government that was created by the State of Illinois in 1984 to manage the Fox Chain. A permit is required for aquatic herbicide treatment or for other lake alterations. The overall water quality of Dunn's lake is poor, with high phosphorus and TSS concentrations. Dunn's Lake is a shallow lake and sediment is easily resuspended in the water column by wind, wave, boat and carp action that disturbs the bottom.

Following are highlights of the water quality and aquatic macrophyte surveys from the 2014 monitoring season. The complete data sets for water quality and aquatic plant sampling conducted on Dunn's Lake can be found in Appendix A of this report, and discussed in further detail in the following sections.

- ◆ Average water clarity was 1.22 ft., which is a 26% decrease since 2002 and is below the Lake County median Secchi depth.
- ◆ Water clarity is influenced by the amount of particles in the water column; this is measured by total suspended solids (TSS). Dunn's Lake average TSS concentration for 2014 was 33.2 mg/L, which increased by 21% since the 2002 sampling and is above the Lake County median of 8.2 mg/L.
- ◆ In 2014 nutrient availability indicated that Dunn's Lake is phosphorus limited May through September with an average TN:TP ratio 25:1. Most of the lakes in Lake County tend to be phosphorus limited, meaning addition of phosphorus to the lake ecosystem can affect change in the lake, such as increased algal populations.
- ◆ The 2014 average total phosphorus concentration was 0.107 mg/L for Dunn's Lake, which exceeds the Illinois Environmental Protection Agency (IEPA) impairment level of 0.05 mg/L. Algae is able to thrive due to phosphorus concentrations in the water that are nearly twice as high as the median phosphorus concentration of other lakes throughout Lake County.
- ◆ The trophic state index value (TSI_p) is 71.5, which indicates Dunn's Lake is between eutrophic and hypereutrophic states and is ranked 117 out of 173 lakes in Lake County.
- ◆ For the entire sampling season, the DO concentrations were at least 5 mg/L from the surface to the bottom in Dunn's Lake.
- ◆ Additionally, DO never reached anoxic conditions in Dunn's Lake (<1mg/L).
- ◆ The aquatic macrophyte survey showed that 40% of the sites sampled had plant coverage. To maintain a healthy fishery, the Illinois Department of Natural Resources suggests plant coverage of 20% to 40%.
- ◆ A total of 9 plant species were present with the most dominant being White Water Lily and Coontail.
- ◆ Eurasian Watermilfoil (EWM), an exotic invasive species, was found in Dunn's Lake at 5.1% of the sampling sites.
- ◆ Dunn's Lake has one official state licensed swimming beach at Fox Lake Vacation Village. From 2000 to 2014 Fox Lake Vacation Village beach has had 28 beach closures related to high bacteria levels, 2 of those closings were in 2014.

Dunn's Lake is in the Fox River Watershed spans both Wisconsin and Illinois

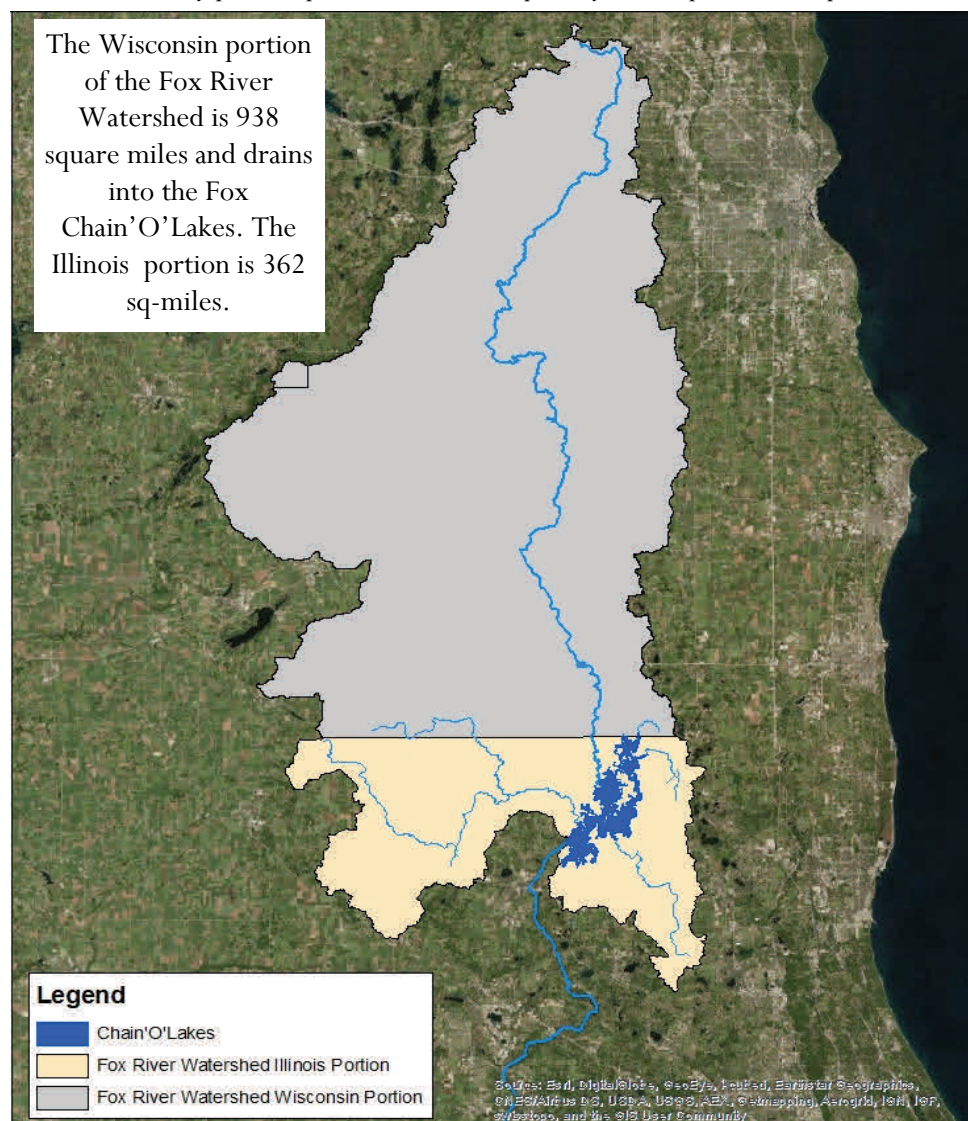
LAKES SAMPLED IN 2014

BANGS LAKE
BLUFF LAKE
CEDAR LAKE
CHANNEL LAKE
CRANBERRY LAKE
COUNTRYSIDE LAKE
DUNNS LAKE
FOX LAKE
GRASS LAKE
LAKE CATHERINE
LAKE MARIE
LONG LAKE
MATTHEWS LAKE
NIPPERSINK LAKE
PETITE LAKE
PISTAKEE LAKE
REDHEAD LAKE
SPRING LAKE
THIRD LAKE
WOOSTER LAKE

WATERSHED

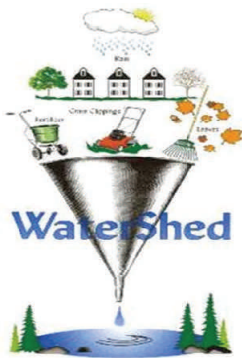
Dunn's Lake is part of the Chain O' Lakes drainage basin of the Fox River Watershed. The Fox River Watershed is a large watershed that spans both Illinois and Wisconsin. The Fox River Watershed has its headwaters in Wisconsin and flows south into Illinois and eventually discharges into the Illinois River. The Fox Chain'O'Lakes are a result of the last episode of glaciation, that left depressions filled with meltwater, forming the current lakes. The Chain'O'Lakes is composed of ten lakes connected by the Fox River and another five lakes that are connected by small canals and channels that can have limited access.

The Wisconsin portion of the Fox River Watershed is approximately 600,000 acres (938 sq-miles). The Illinois portion of the Upper Fox River Watershed drains land from McHenry and Lake counties and is approximately 2.5 times smaller than the Wisconsin portion of the watershed at about 230,000 acres (362 sq-miles). Land use upstream in Wisconsin plays a significant role in the water quality of the Chain'O'Lakes. Since the Fox Chain'O'Lakes have such a large drainage basin and a significant source of water flow from the Fox River and its tributaries, the inflow of water can carry more nutrients and sediments into the lakes. The large watershed makes it difficult to identify possible pollution sources, especially for nonpoint source pollution.



WATERSHED

Everyone lives in a watershed! A watershed is an area of land where surface water from rain and melting snow meet at a point, such as a lake or stream.

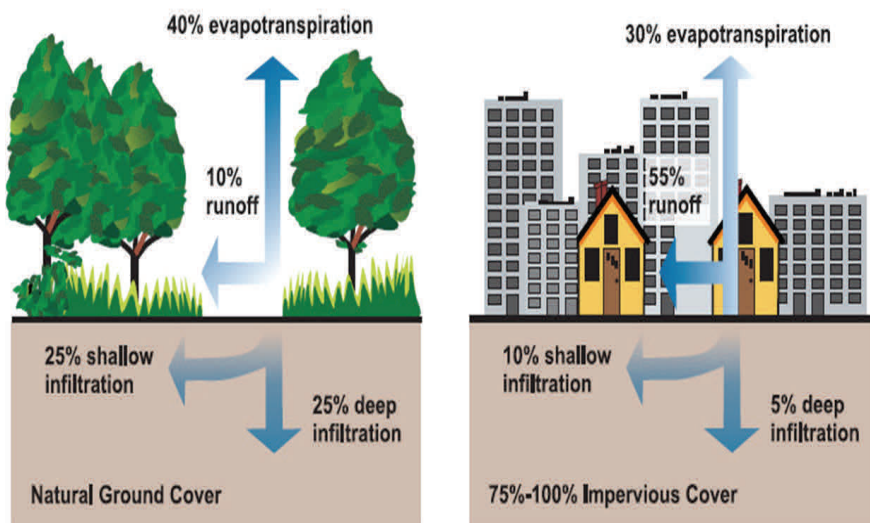


Dunn's Lake receives water from surrounding lands and discharges to the south eventually draining to Nippersink Lake. In 1972, the Fox Lake Tall Oaks wastewater treatment plant began operation to service the homes in Vacation Village and Leisure Village near Dunn's Lake. The facility's design average flow (DAF) currently is 0.50 million gallons per day (MGD) and the design maximum flow is 1.25 MGD. A pipe allows water from the pond to flow into the marina if the water level were to increase from stormwater inputs. In addition, all parameter loads were significantly below their max allowable for the year (Appendix A). Sewage treatment plants can play a role in nutrient dynamics and flow within the lake; based on their discharged effluent.

The size of the watershed relative to the size of the lake is also an important factor in determining the amount of pollutants in the lake. The Dunn's Lake watershed is 455 acres, and the watershed to lake surface area ratio is approximately 26:1, which is a large watershed-to-lake ratio. The majority of the watershed's land use is residential (29%), followed by open space (26%), surface water (16%), and wetlands (11.4%). The Fox Lake Country club just north of Dunn's lake is a golf course and included in the open space category. Based on the amount of impervious surfaces each land use contributes varied amounts of runoff. Impervious surfaces (parking lots, roads, buildings, compacted soil) do not allow rain to infiltrate into the ground; a greater amount of runoff is generated than in more natural areas that allow water to infiltrate. The major sources of runoff for Dunn's Lake is the urban and built up land which totals approximately 38.5% of the it's watershed. Runoff from impervious surfaces also carry with it nutrients, sediment, and debris which can be washed into the lake.

Land Use Data from the 2009 TMDL Upper Fox River Watershed/Chain O'Lakes Report

Figure 1



As a watershed is developed, the amount of impervious surface increases resulting in a greater influx of runoff entering our waters due to reduced infiltration of rainwater into the ground.

| Land Use | % of Watershed |
|--|----------------|
| Agriculture | 0.3 |
| Disturbed Land | 0.2 |
| Forested, Grasslands, Vegetation | 7.2 |
| Government and Institutions | 0.5 |
| Residential | 29.2 |
| Open Lands | 26.0 |
| Retail/Commerce | 0.5 |
| Transportation, Utilities, Communication | 8.8 |
| Water | 15.9 |
| Wetlands | 11.4 |
| Total | 100.0 |

WATER CLARITY

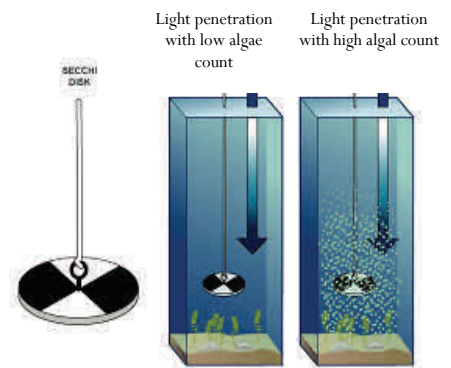
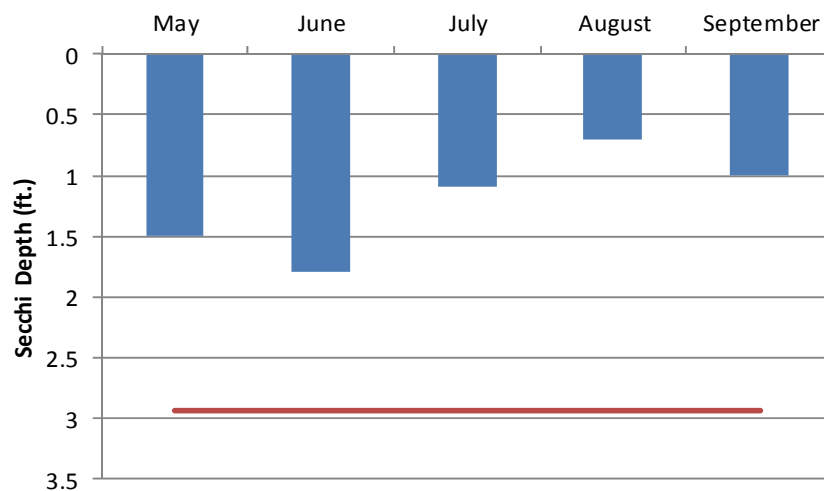
Water clarity, or water transparency, is an indicator of water quality related to chemical and physical properties.

Water clarity is typically measured with a Secchi disk and indicates the amount of light penetration into a body of water. It can also provide an indirect measurement of the amount of suspended material in water (see the total suspended solids sections). A number of factors can interfere with light penetration and reduce water transparency. This includes: algae, water color, re-suspended bottom sediments, eroded soil, boat propellers, and invasive species such as Zebra Mussels that can filter out plankton and improve water clarity.

The 2014 average water clarity in Dunn's Lake was 1.22 ft., a 26% decrease in water clarity from 2002 sampling where the Secchi depth was 1.54 ft. Compared to other lakes in Lake County, Dunn's lake is below the median Lake County Secchi depth of 2.95 ft. The Secchi disk depth was greatest in June (1.79 ft) and the lowest secchi depth in August (0.7 ft.) as shown in Figure 2. Algae blooms observed in August may be attribute to the lower Secchi disk depth observed in this month. Dunn's lake had the third lowest water clarity readings among the lakes sampled in 2014 within the Fox Chain (Figure 3).

Figure 2

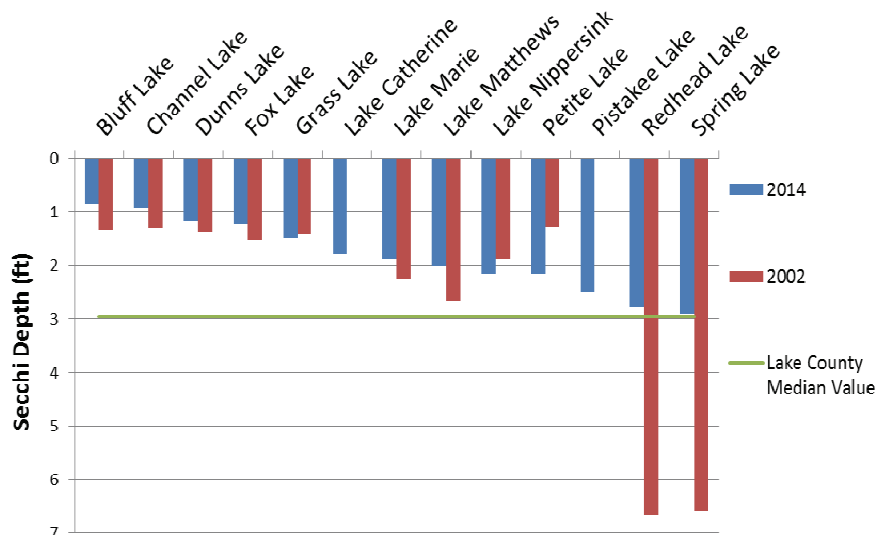
2014 Dunn's Lake Secchi Depth



DUNN'S LAKE AVERAGE
SECCHI WAS 1.22 FT.,
WHICH IS BELOW THE
LAKE COUNTY MEDIAN

Figure 3

2002 vs. 2014 Secchi Depth Comparison Fox Chain'O'Lakes



WHAT YOU CAN DO TO IMPROVE WATER QUALITY IN DUNN'S LAKE

- Do not throw leaves, grass clippings, pet waste, and other organic debris into the street or driveway. Runoff carries these through storm sewers, directly into Lake Matthews.
- Build a rain garden to filter run-off from roofs, driveways, and streets. This allows the phosphorus to be bound to the soil so it does not reach surface waters
- Sweep up fertilizer that is spilled or inadvertently applied to hard surface areas, do not hose it away.

VOLUNTEER LAKE MONITORING PROGRAM (VLMP)

The VLMP was established in 1981 by the Illinois Environmental Protection Agency (IEPA) to be able to collect information on Illinois inland lakes, and to provide an educational program for citizens. The volunteers are primarily lakeshore residents, lake owners/managers, members of environmental groups, and citizens with interest in a particular lake.

The VLMP relies on volunteers to gather information on their chosen lake. The primary measurement by volunteers is Secchi depth (water clarity). Water clarity can provide an indication of the general water quality of the lake. Other observations such as water color, suspended algae and sediment, aquatic plants and odor are also recorded. The sampling season is May through October with measurements taken twice a month. In 2014, there were 48 lakes participating in Lake county.

Currently Dunn's Lake is need of a volunteer lake monitor. It is recommended that Dunn's Lake participates in VLMP. Participating provides annual data that helps document water quality impacts and support lake management decisions.



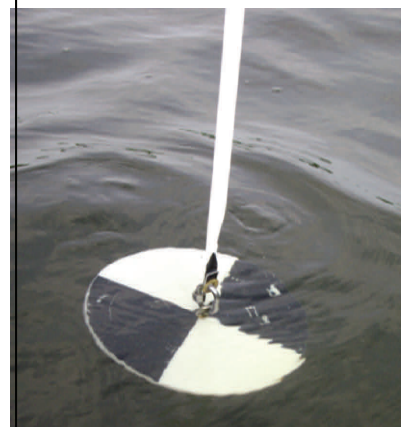
For more information visit:

[www.epa.state.il.us/
water/vlmp/
index.html](http://www.epa.state.il.us/water/vlmp/index.html)



**PLEASE CONSIDER
PARTICIPATING IN THE
VOLUNTEER LAKE
MONITORING PROGRAM ON
DUNN'S LAKE.**

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TOTAL SUSPENDED SOLIDS

Another measure of water clarity is turbidity, which is caused by particles of matter rather than dissolved organic compounds. Suspended particles dissipate light, which affects the depth at which plants can grow. The total suspended solid (TSS) parameter represents the concentration of all organic and inorganic materials suspended in the lake's water column. Typical inorganic components of TSS is referred to as non-volatile suspended solids (NVSS). NVSS originate from weathering and erosion of rocks and soils in the lake's watershed and re-suspension of lake sediments. The organic portion of TSS is called volatile suspended solids (TVS). TVS is mostly composed of algae and other organics, such as decaying plant and animal matter.

2014 TSS concentrations in Dunn's Lake averaged 33.2 mg/L which is approximately four times greater than the Lake County median of 8.2 mg/L. High TSS values are typically correlated with poor water clarity (Secchi disk depth) and can be detrimental to many aspects of lake ecosystem including the plant and fish communities.

**Dunn's Lake
Total Suspended Solids Concentrations**

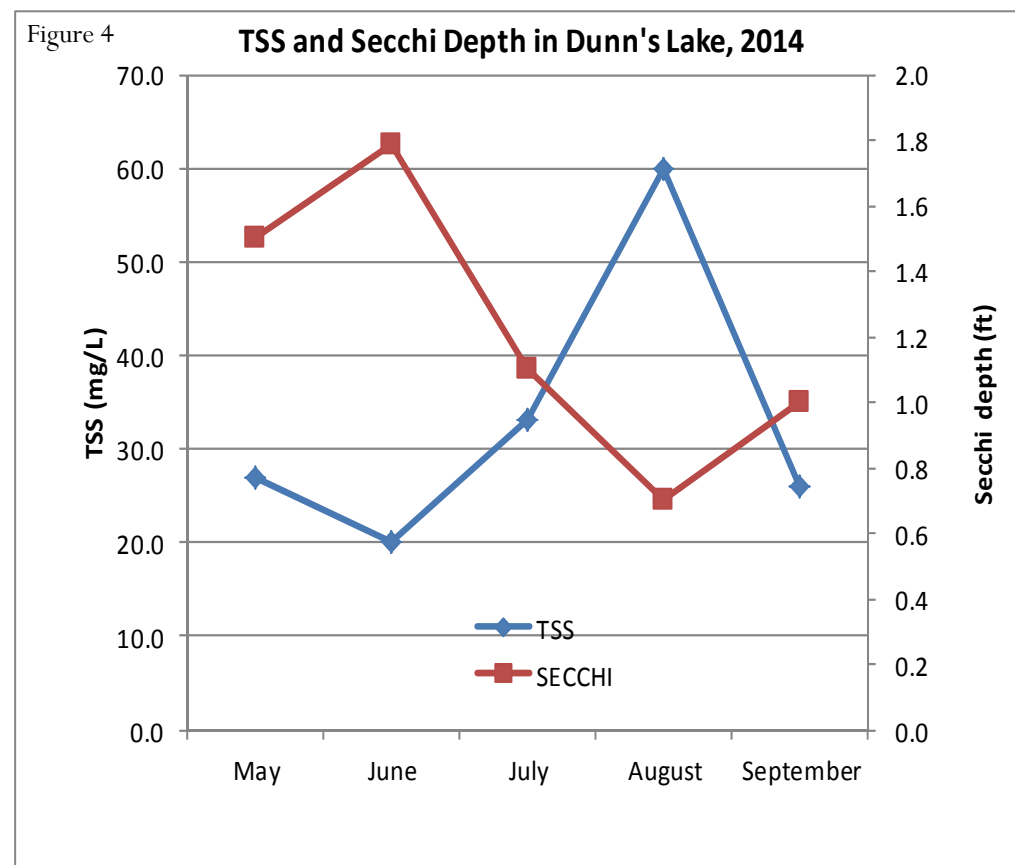
| Month | 2014 TSS (mg/L) | 2002 TSS (mg/L) |
|----------------|--------------------|--------------------|
| May | 27 | 16 |
| June | 20 | 16 |
| July | 33 | 33 |
| August | 60 | 40.4 |
| September | 26 | 27 |
| <i>Average</i> | 33.2 | 26.4 |

TOTAL SUSPENDED SOLIDS (CONTINUED)

The 2014 concentration is an increase of 21% in TSS since the 2002 sampling from 27.5 mg/L (2002) to 33.2 mg/L (2014). TSS ranged from 20 mg/L (June) to 60 mg/L (August). The higher TSS values in August correlate with a lowest Secchi depth (Figure 4). The calculated median nonvolatile suspended solids (NVSS) for the season was 14.9 mg/L. Lake's with median surface NVSS greater than 12 mg/L have a TSS impairment. Dunn's Lake is 1 of 4 lakes in the Fox Chain that have a TSS impairment based on 2014 data. Additionally, Dunn's is the only lake of the four with TSS impairments that is not directly connected to the Fox River.

The August TSS concentration was 60 mg/L with a calculated NVSS of 38.5 mg/L. This means that 64% of the suspended solids in the water can be attributed to sediment in August. The increase in turbidity could have been caused by heavy rainfall events occurring in August (6.02 inches of precipitation), washing in sediments that became suspended in the water column. In addition, Dunn's Lake high TSS can be attributed to wind, wave, and carp action. While the Fox Lake Tall Oaks facility does discharge TSS; all values were below their maximum allowable load.

The algae and organic matter in the water column was also high in Dunn's Lake. The average TVS for the monitoring season was 162 mg/L which is above the county median of 121.0 mg/L by 34%. Visible blue-green algae blooms in August also contribute to the high TSS value observed in the August sample and is also a reason for the decrease in Secchi depth observed in this month as well.



TSS

Total Suspended Solids

TSS are particles of algae or sediment suspended in the water column.

TVS

Total Volatile Solids

TVS represents the fraction of total solids that are organic in nature, such as algae cells

NVSS

Non-Volatile Suspended Solids

NVSS represents the non-organic clay and sediments that are suspended in the water column.

TDS

Total Dissolved Solids

TDS are the amount of dissolved substance such as salts or minerals in the water after evaporation.

Secchi depth and TSS are inversely related, meaning when there are high TSS concentrations there are low Secchi depth readings.

NUTRIENTS: PHOSPHORUS

Organisms take nutrients in from their environment. In a lake, the primary nutrients needed for aquatic plant and algal growth are phosphorus (P) and nitrogen (N). Phosphorus is a vital nutrient for converting sunlight into usable energy and essential for cellular growth and reproduction. Phosphorus occurs in dissolved organic and inorganic forms or attached to sediment particles. Phosphates, the inorganic form, are preferred for plant growth but other forms can be used. Phosphorus builds up in the sediments of a lake. When it remains in the sediments it is generally not available for use by algae, however, various chemical and biological processes can allow phosphorus to be released from the sediment and be available in the water column. For instance, carp can churn up the bottom of lake re-suspending sediment and phosphorus into the water column. During anoxic conditions, P can be released from sediment, and then mixed in the water column when the lake de-stratifies.

2014 phosphorus concentrations in Dunn's Lake averaged 0.107 mg/L. Average TP values are above the Lake County median (0.068 mg/L) and there was an 12% increase in P concentrations since 2002 from 0.09 mg/L (2002) to 0.107 mg/L (2014). Dunn's Lake exceeded the Illinois EPA standard of 0.05 mg/L for phosphorus in all samples. When surface total phosphorus exceeded 0.05mg/L, the lake is considered impaired for phosphorus and may support high densities of algae and aquatic plants. This can in turn reduce water clarity and dissolved oxygen. August had the highest TP concentration with a value of 0.183 mg/L (Figure 5). Large blue-green algae blooms were observed in August as a result of increased nutrients (see Harmful Algal Bloom section).

Phosphorus originates from a variety of sources, many of which are related to human activities which including: human and animal waste, soil erosion, detergents, septic systems, common carp, and runoff from lawns. Fox Lake Trail Oak Sanitary wastewater is discharged into an unnamed creek that goes into Dunn's Lake. This could be a source of phosphorus, especially during heavy precipitation events that may overburden wastewater treatment facilities although no violations were reported in 2014. A heavy precipitation event occurred in August 2014 with 6.03 inches of rainfall. Failing septic systems in the area could exacerbate nutrient conditions in the lake as well. It is important to regularly inspect septic systems.

WHAT HAS BEEN DONE TO REDUCE PHOSPHORUS LEVELS IN ILLINOIS?

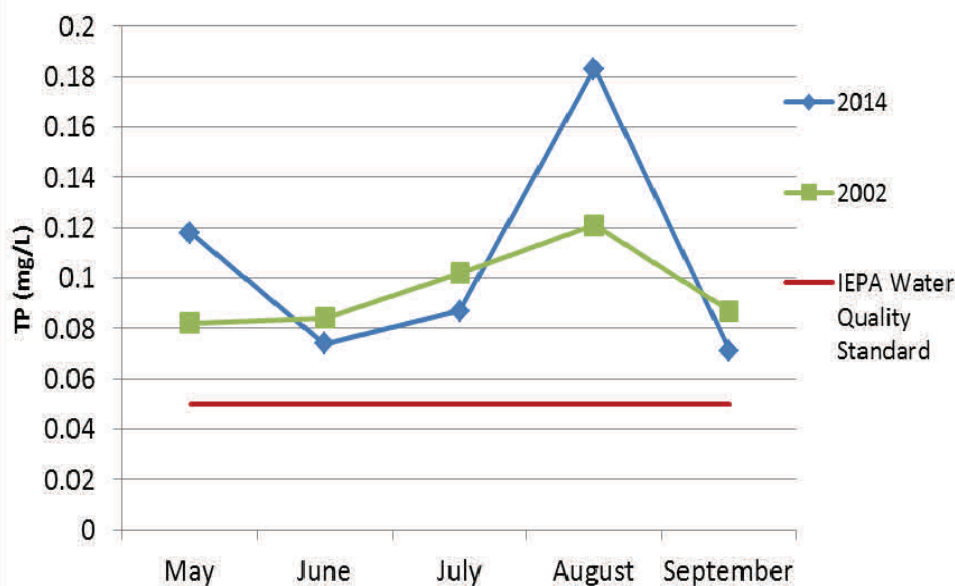
2007- The Village of Antioch passed an ordinance banning the use of fertilizers containing phosphorus and fertilizer restriction within 10 feet of waterways.

July 2010—The state of Illinois passed a law to reduce the amount of phosphorus content in dishwashing and laundry detergent

July 2010: The state of Illinois passed another law restricting the use of lawn fertilizers containing phosphorus by commercial applicators.

Figure 5

Dunn's Lake Total Phosphorus

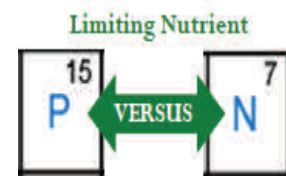


| Month | TP (mg/L) |
|-----------|-----------|
| May | 0.118 |
| June | 0.074 |
| July | 0.087 |
| August | 0.183 |
| September | 0.071 |
| Average | 0.107 |

NUTRIENTS: NITROGEN

Nitrogen, in the forms of nitrate (NO_3^-), nitrite (NO_2^-), or ammonium (NH_4^+) is a nutrient needed for plant and algal growth. Nitrogen enters the ecosystem in a several chemical forms and a lake's nitrogen source can vary widely. Sources of nitrogen include septic systems, animal feed lots, agricultural fertilizers, manure, industrial waste waters, and sanitary landfills, and atmospheric deposition. All inorganic forms of nitrogen (NO_3^- , NO_2^- , and NH_4^+) can be used by aquatic plants and algae. If these inorganic forms exceed 0.3 mg/L, there is sufficient nitrogen to support summer algae blooms. In May and June of 2014, the inorganic forms of nitrogen were greater than 0.3 mg/L in Dunn's Lake. These increased levels of nitrogen can be from runoff from surrounding land use, especially fertilizer use right after spring thaw, and organic material being flushed into the lake system from spring rains. Septic failures may also play a role.

Total Kjeldahl nitrogen is a measure of organic nitrogen, and is typically bound up in algal and plant cells. Average total Kjeldahl nitrogen (TKN), an organically (algae) associated form of nitrogen, in Dunn's Lake was 2.33 mg/L, which is higher than the Lake County median of 1.170 mg/L. It is also higher than the TKN values for the other lakes within the Fox Chain for the 2014 season. This higher TKN value is most likely related to the sewage treatment facility which discharges into an unnamed creek that goes into Dunn's Lake. While the facility had no violations of their maximum load, wastewater tends to be higher in organic nitrogen and ammonia. The TN:TP ratio looks at TKN + NO_3^- to total phosphorus. This ratio can indicate whether plant and algae growth in a lake is limited by nitrogen or phosphorus. Typically ratios of less than 10:1 suggest the lake is limited by nitrogen, while ratios greater than 20:1 are limited by phosphorus. Dunn's Lake has a TN:TP ratio of 25:1, meaning the lake is phosphorus limited and additions of phosphorus can impact changes in the lake



TN:TP Ratio

<10:1 =
nitrogen limited

>20:1 =
phosphorus limited

TN:TP Ratio on Dunn's:

25:1

**Dunn's Lake
is P-limited**

WAYS TO REDUCE NUTRIENTS IN YOUR LAKE

Phosphorus and nitrogen originate from a variety of sources, many of which are related to human activities. Some sources include: human and animal waste, soil erosion, detergents, septic systems, common carp, and runoff from lawns and fields, fertilizers, manure and atmospheric deposition. Installing best management practices around Dunn's Lake, such as buffer strips, planting more native plants, rain gardens, and using minimal amount of fertilizer are ways to help reduce nutrient runoff from your own property to the lake. Below are some suggestions to improve water quality:

Waterfowl management (ducks and geese)

- Do not feed or encourage others to feed waterfowl
- Use good landscaping practices to discourage waterfowl. Landscapes with taller plants and shrubbery can discourage geese.

Fertilizer use:

- If you apply fertilizers to lawns and gardens, have your soil tested to determine how much fertilizer to apply.
- Check the weather! Avoid fertilizing before heavy rain events.
- Sweep up any fertilizer which is spilled on impervious surfaces such as walks and driveways.
- Do not spread fertilizer within 75 feet of surface waters or wetlands

Pet Waste Disposal

- Regularly scoop up and dispose of pet waste.

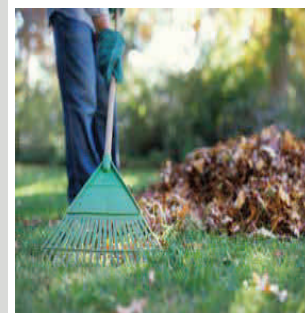
Landscaping Practices

- Consider native vegetation as a quality alternative to lawns. Native vegetation provides a more diverse plant community, and can filter out nutrients and also provides habitat for important pollinators.
- Plant a buffer strip of native plants (at least 20 feet) between the lake's edge and your property.

Keep fall leaves out of the storm drains

- Never rake leaves into or near storm drains, ditches, creeks, or on lakeshore.

Regularly inspect your septic systems



TROPHIC STATE INDEX

Trophic state is another indicator of water quality and lake productivity. The Trophic State Index (TSI) value is based on phosphorus (TSIp) and Secchi (TSIsd) and are calculated from the monitoring data. Lakes are classified into 4 main categories of trophic states that reflect nutrient levels and productivity. The 4 categories are: oligotrophic, mesotrophic, eutrophic, and hypereutrophic. These range from nutrient poor and least productive to most nutrient rich and most productive.

A lake's response to additional phosphorus is an accelerated rate of eutrophication. Eutrophication is a natural process where lakes become increasingly enriched with nutrients. Lakes start out with clear water and few aquatic plants and over time become more enriched with nutrients and vegetation until the lake becomes a wetland. This process takes thousands of years. However, human activities that supply lakes with additional phosphorus and nitrogen (such as fertilizer, household products, waste by-products, etc.) are accelerating the eutrophication process.

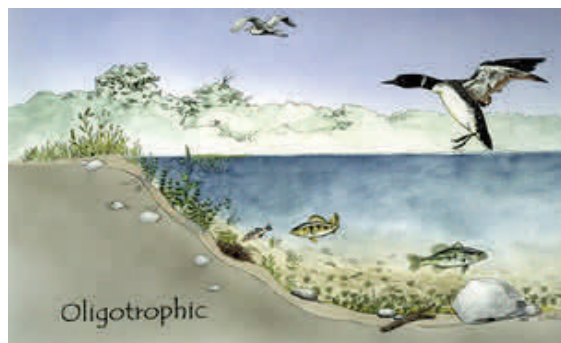
In 2014, Dunn's Lake was considered between eutrophic and hypereutrophic with a TSIp value of 71.5. Based on the TSIp, Dunn's Lake ranked 117 out of 173 lakes studied by the LCHD-ES from 2000–2014.

**LAKE COUNTY
AVERAGE**
TSIP = 67.3

DUNN'S LAKE
TSIP = 71.5

**TROPHIC
STATE:**
HYPEREUTROPHIC

RANK = 117 /173



OLIGOTROPHIC

Lakes have low nutrients and are generally deep and free of weeds or large algae blooms. They do not support large fish populations.



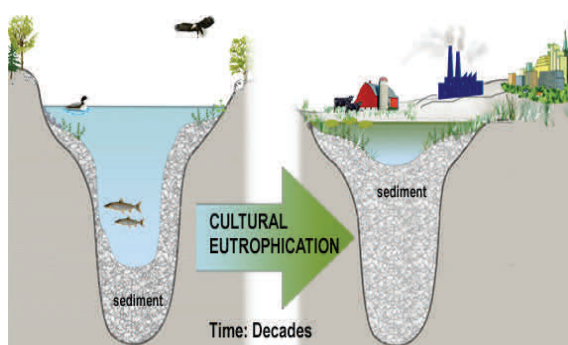
MESOTROPHIC

Lakes have medium nutrients and intermediate level of productivity. Mesotrophic lakes typically have clear water with beds of submerged aquatic plants. Mesotrophic lakes can have a diverse fish population.



EUTROPHIC

Lakes are high in nutrients, and are usually weedy or subject to frequent algae blooms. Eutrophic lakes often support large fish populations but are also susceptible to oxygen depletion. Increased sedimentation also is typical of eutrophic lakes



CULTURAL EUTROPHICATION

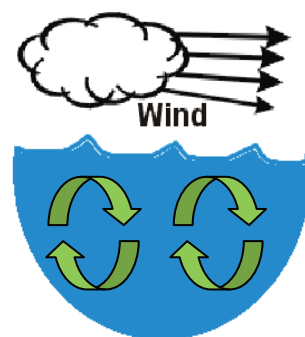
An enrichment and accumulation of a lake with nutrients, sediments, and organic matter from the surrounding watershed. It can be a natural process in lakes, occurring as they age through geologic time. Human activity that occurs in the watershed can accelerate eutrophication, known as cultural eutrophication and can lead to increased algal growth, increased rooted plant growth, and lower dissolved oxygen concentrations.

STRATIFICATION

A lake's water quality and ability to support fish are affected by the extent to which the water mixes. The depth, size, and shape of a lake are the most important factors influencing mixing, but climate, lakeshore topography, inflow from streams and vegetation also play a role. Variations in density caused by different temperatures can prevent warm and cold water from mixing former layers of different temperatures and densities called stratification.

For example: when lake ice melts in early spring, the temperature and density of lake water will be similar from top to bottom. Since it is uniform throughout the water column, the lake can mix completely recharging the bottom water with oxygen and bringing nutrients up to the surface. Some lakes in summer experience stratification where the lake is dividing into three zones: epilimnion (warm surface layer), thermocline (transition zone between warm and cold water) and hypolimnion (cold bottom water). Stratification traps nutrients released from bottom sediments in the hypolimnion and prevents mixing.

Dunn's Lake is a shallow lake and therefore does not thermally stratify during the summer months. Lake temperatures remained fairly constant throughout the depth of the lake. Dunn's Lake is considered a polymictic lake since it is too shallow to develop thermal stratification, meaning their water can mix from top to bottom throughout the ice free period.



Shallow lakes, like Dunn's Lake, are more prone to mixing from wind and wave action. It is considered polymictic since it does not stratify and can mix frequently during the ice free season.

DISSOLVED OXYGEN

Dissolved oxygen (DO) concentrations in Dunn's Lake were adequate (>5.0 mg/L) throughout the monitoring season. This is due to the lake's shallow morphometry, which helps keep Dunn's Lake well mixed. Average DO concentrations ranged from 15.74 mg/L (September) to 7.91 mg/L (August). Hypoxic conditions ($DO < 1.0$ mg/L) never occurred. When DO concentration drop below 1.0 mg/L, biological and chemical processes release nutrients into the water, which are sequestered in the hypolimnion due to stratification and can be released into the surface waters. However, since stratification and anoxic conditions did not form in Dunn's Lake this type of nutrient release is not a significant source of phosphorus to the lake.

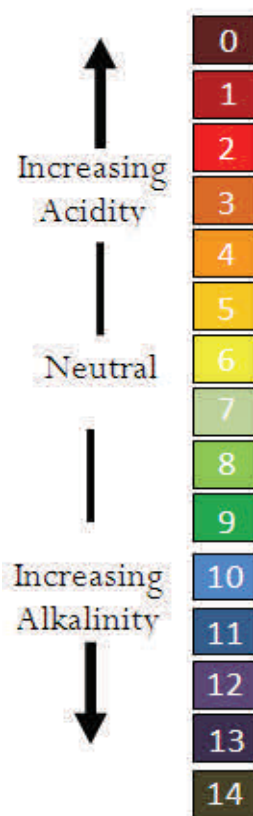
ALKALINITY AND PH

Alkalinity is the buffering capacity of a water body. It measures the ability of water bodies to neutralize acids and bases to maintain a stable pH. In a lake, alkalinity acts to buffer lakes from the effects of acid rain. Alkalinity comes from rocks, soils, salts, and certain plant activities. If a lakes watershed contains large quantities of calcium carbonate (CaCO_3 , limestone), the surface waters tend to be more alkaline; while granite bedrock does not have high amounts of CaCO_3 and therefore lacks alkaline materials to buffer acidic inputs.

pH is a measure of the hydrogen ion concentration of water. As the hydrogen ions are removed, pH goes up or halts its decline. A well buffered lake also means that daily fluctuations of CO_2 concentrations result in only minor changes in pH throughout the day. Aquatic organisms benefit from stable pH. Each organism has an ideal pH threshold, but most aquatic organisms prefer pH of 6.5—8.0. pH values < 6.5 or > 9.0 cause a water quality impairment.

In 2014, the average alkalinity (CaCO_3) concentration in Dunn's lake was 200 mg/L which is 24% greater than the Lake County median of 161 mg/L. The USEPA considers lakes with CaCO_3 concentrations greater than 20 mg/L to not be sensitive to acidification.

Dunn's Lake's average pH in 2014 was 8.33 which is equal to the Lake County median and within the preferable pH range for aquatic organisms.




The pH scale ranges from 0 to 14. a pH of 7 is considered neutral. Substances with a pH of less than 7 are acidic, and greater than 7 are basic.

CONDUCTIVITY AND CHLORIDES

Another parameter measured during the 2014 monitoring season that is important in comparing data from year to year is conductivity. Conductivity is the measure of different chemical ions in solution. As the concentration of these ions increases, conductivity increases. The conductivity of a lake is dependent on the lake and watershed geology, size of the watershed flowing into the lake, the land use, evaporation, and bacterial activity. Conductivity in urban areas has been shown to be highly correlated with chloride ions found in road salt mixes (Figure 6). In 2014, Dunns lake's average conductivity was 0.8102 mS/cm. This is above the county median of 0.7900 mS/cm. This parameter increased since the 2002 sampling by 8% increase.

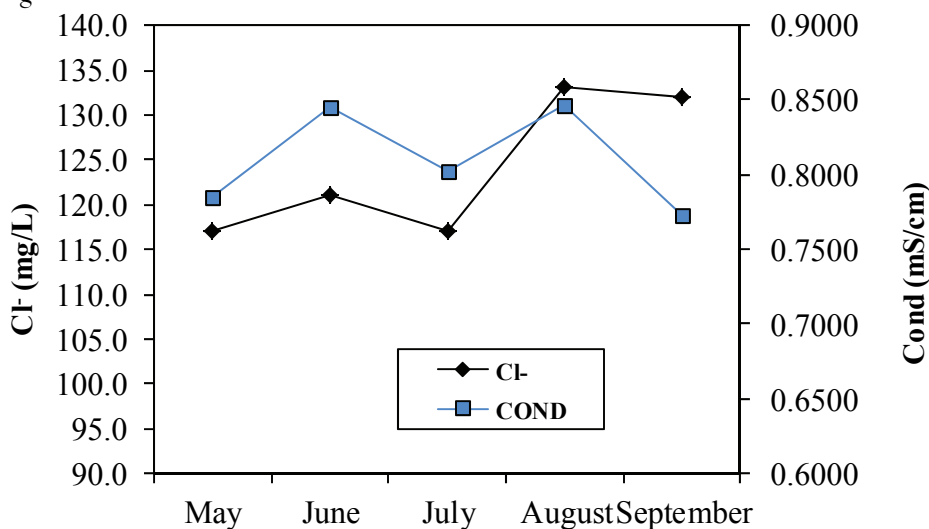
One of the most common dissolved solids is road salt used in winter road deicing. Most road salt is sodium chloride, calcium chloride, potassium chloride, magnesium chloride or ferrocynaide salts. Dunns Lake's 2014 average chloride concentration was 124 mg/L which is also below the Lake County median of 139 mg/L. The United States Environmental Protection agency has determined that chloride concentrations higher than 230 mg/L can disrupt aquatic systems. Chloride ions do not break down and accumulate within a watershed. High chloride concentrations may make it difficult for many of our native plant species to survive while many of our invasive species such as Eurasian Watermilfoil, Cattail, and Common Reed are tolerant to high chloride levels. As salts dissolve and move through the watershed with snowmelt and stormwater runoff they tend to remain in the water cycle by settling.

**THE CRITICAL
VALUE FOR
CHLORIDES IN
AQUATIC SYSTEMS
IS 230 MG/L.**



**230 mg/L = 1 teaspoon
of salt added to
5 gallons of water.**

Figure 6



ICE FACTS

- De-icers melt snow and ice. They provide no traction on top of snow and ice.
- Anti-icing prevents the bond from forming between pavement and ice.
- De-icing works best if you plow/shovel before applying material.
- Pick the right material for the pavement temperatures.
- Sand only works on top of snow as traction. It provides no melting.
- Anti-icing chemicals must be applied prior to snow fall.
- NaCl (Road Salt) does not work on cold days, less than 15° F.

| Pavement | One Pound of | Melt times |
|----------|-----------------|---|
| 30 | 46.3 lbs of ice | 5 min. |
| 25 | 14.4 lbs of ice | 10 min. |
| 20 | 8.6 lbs of ice | 20 min. |
| 15 | 6.3 lbs of ice | 1 hour |
| 10 | 4.9 lbs of ice | Dry salt is ineffective and will blow away before it melts anything |

Kerry McCaughey LCHD Lab staff uses black light technology to report E. coli beach data.



BEACHES

There is one state licensed swimming beach on Dunn's Lake at Fox Lake Vacation Village. This beach has been monitored every two weeks from mid May to the end of August by LCHD-ES since 2000. The water samples are tested for E. coli bacteria, which are found in the intestines of warm-blooded animals. While not all strains of E. coli are the same, certain strains can make humans sick if ingested in high enough concentrations. If water samples come back high for E. coli (>235 E. coli/100 ml), the management body for the bathing beach is notified and a sign is posted indicating the swim ban. E. coli is used as an indicator organism, meaning that high concentrations of E. coli might suggest the presence of harmful pathogens such as, Salmonella, Giardia, etc.

From 2000 to 2014 Fox Lake Vacation Village beach has had 28 beach closures related to bacteria levels. In 2014, there were a total of two beach closings in early August (Aug 1st and Aug 5th).

There are many ways E.coli can end up in a swimming beach. Heavy rainfall and strong wind associated with storms can cause the water to become cloudy with sediment from the lake bottom. Stormwater from rain can also wash in other particles from lawns, streets, and buildings. This sediment and stormwater may contain high concentrations of E. coli. Another source of E. coli contamination is the feces of gulls, geese, and other wildlife. The Fox Lake Vacation Village beach is also just downstream of the Fox Lake Tall Oaks Wastewater plant where increased nutrients of both nitrogen and phosphorus could contribute to increased algae activity.

DUNN'S LAKE HAD 2 BEACH CLOSURES IN 2014. WHEN WATER SAMPLES EXCEED >235 E.COLI/100 ML; A SWIMMING BAN IS IN PLACE.

| Date | E.coli |
|----------|------------------------|
| 8/1/2014 | 260.2 E.coli/100 mL |
| 8/5/2014 | 435.2 E.coli/100mL |

HOW TO PREVENT ILLNESS AND BEACH CLOSURE



**SWIMMING
PROHIBITED
BEACH CLOSED**

Practicing common sense and good hygiene will go a long way in preventing illness from swimming beaches.

- If you are sick or have diarrhea, do NOT swim.
- Do NOT drink the water while swimming.
- Avoid swimming during heavy algae blooms.
- Keep pets, ducks, and geese out of the beach area
- Children who are not toilet trained should wear tight-fitting rubber or plastic pants.
- Take a shower before entering the water, and have kids take frequent bathroom breaks.
- Wash your hands after exiting the lake.
- Avoid swimming during algae blooms
- Identify sources of pollution (ex: failing septic systems, stagnant standing water near the beaches, creeks and storm drains).

BLUE-GREEN ALGAE

Algae are important to freshwater ecosystems and most species of algae are not harmful. Algae can grow quickly in water and is often associated with increased concentrations of nutrients such as nitrogen and phosphorus. Blue-green algae, or "cyanobacteria" are a type of algae that can bloom and produce toxins, which are similar to bacteria in structure but utilize photosynthesis to grow. They have no nucleus and lack the photosynthetic pigments found in algae. They usually are too small to be seen individually, but can form visible colonies that can cover large areas of lakes. Certain species of blue-green algae can produce toxins that could pose a health risk to people and animals when they are exposed to them in large enough quantities.

Blooms can last for an extended period of time and can deplete the oxygen and block sunlight in the water that other organisms need to live. The water can appear blue-green, bright green, brown, or red and may look like paint floating on the water. Not all blue-green algae produce harmful toxins. The three types of cyanobacteria that are often associated with Harmful Algal Bloom (HAB) are the *Anabaena*, *Aphanizomenon*, and *Microcystis*. The presence of these cyanobacteria does not generally mean that the toxins are present in the water. The presence of toxins can only be verified through a sample analyzed in the lab.

A total of 7 water samples were analyzed for Harmful Algal Bloom (HAB) in 2013 at Dunn's Lake. All samples contained a detectable limit of microcystin concentration. The average microcystin concentration on Dunn's Lake was 10.71 ug/L. Samples over 20 ug/L have potential health risks associated with recreational exposure to elevated concentrations and the EPA recommends not to swim in the lake. There was one sample at Dunn's Lake in 2013 that was above 20 ug/L taken on 8/8/2013 at with a concentration of 26.63 ug/L.

Poisoning has caused the death of cows, dogs, and other animals. Most human cases occurred when people swim or ski in affected recreational water bodies during a bloom. If you suspect that you are experiencing symptoms related to exposure to blue-green algae such as stomach cramps, diarrhea, vomiting, headache, fever, muscle weakness, or difficulty breathing contact your doctor or the poison control center.

For more information or to report a blue-green algae bloom, contact the Lake County Health Department Environmental Services (847) 377-8030.

FOR MORE INFORMATION ON BLUE-GREEN ALGAE:

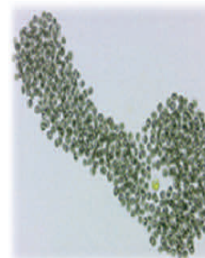
[www.epa.state.il.us/
water/surface-water/
blue-green-algae.html](http://www.epa.state.il.us/water/surface-water/blue-green-algae.html)

TO REPORT BLUE- GREEN ALGAE

BLOOM:
Lake County Health
Department
847-377-8030



Anabaena Sp.



Microcystis Sp.



Aphanizomenon Sp.

| Dunn's Lake | Value |
|--------------------------------------|-------|
| # HAB Samples Collected | 7 |
| # of Non-Detect Samples | 0 |
| Average of Detectable samples (ug/L) | 10.71 |
| Median of samples (ug/L) | 8.63 |
| Samples >20 ug/L | 1 |



Photo: Summer blue-green algal bloom at Vacation Village beach in Dunn's Lake in 2014

BATHYMETRIC MAPS

Bathymetric maps, also known as depth contour maps, display the shape and depth of a lake. They are valuable tools for lake managers because they provide information about the surface area and volume of the lake at certain depths.

This information can then be used to determine how much of the lake loses dissolved oxygen in the summer, how much of the lake bottom can be inhabited by plants, and is essential in the application of whole-lake herbicide treatments, harvesting activities and alum treatments of your lake. Other common uses for the map include sedimentation control, fish stocking, and habitat management.

The LCHD-ES collects field data using Biosonics equipment along with a Trimble GPS unit with sub-foot accuracy. Once collected, the data will be analyzed and imported into ArcGIS for further analysis. In ArcGIS, the contours are drawn and the lake volume is calculated. The Lake County-ES has created bathymetric maps for many of the larger lakes in the county.

The LCHD-ES recommends the creation of an updated bathymetric map for all lakes larger than six acres and can provide the names of several companies that can be hired to do the work. If you are interested in the creation of a bathymetric map of your lake, please contact the LCHD-ES at (847) 377-8030.

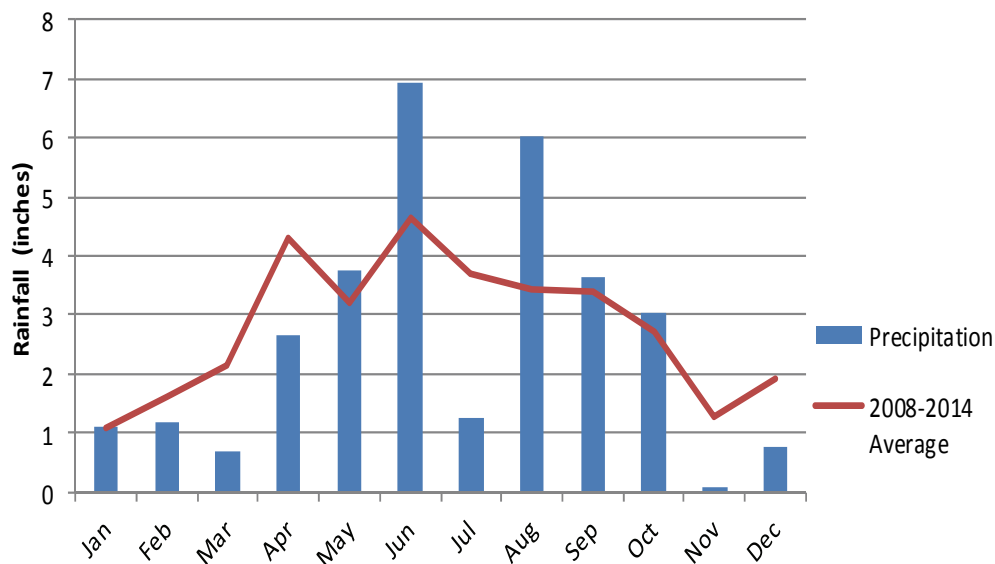
**BATHYMETRIC
MAPS PROVIDE
LAKE MANAGERS
WITH AN
ACCURATE LAKE
VOLUME THAT
CAN BE USED
FOR HERBICIDE
APPLICATION
AND HELP
ANGLERS FIND
POTENTIAL
FISHING SPOTS.**

PRECIPITATION

Precipitation data was obtained from the Lake County Stormwater Management Commission that has several climate monitoring stations. Long Lake, just south-east of the Fox Chain was used to determine monthly precipitation totals. In 2014, May, June, and August were wet months, with rainfall for June and August being greater than 6 inches in precipitation. Heavy precipitation events can be a significant contributor to sediment and nutrients to the overall lake system. Figure 7 shows precipitation totals from the Long Lake station for 2014.

Figure 7

Precipitation Totals for 2014



Left:
Precipitation
totals from
Long Lake
Station in Lake
County

LAKE LEVELS

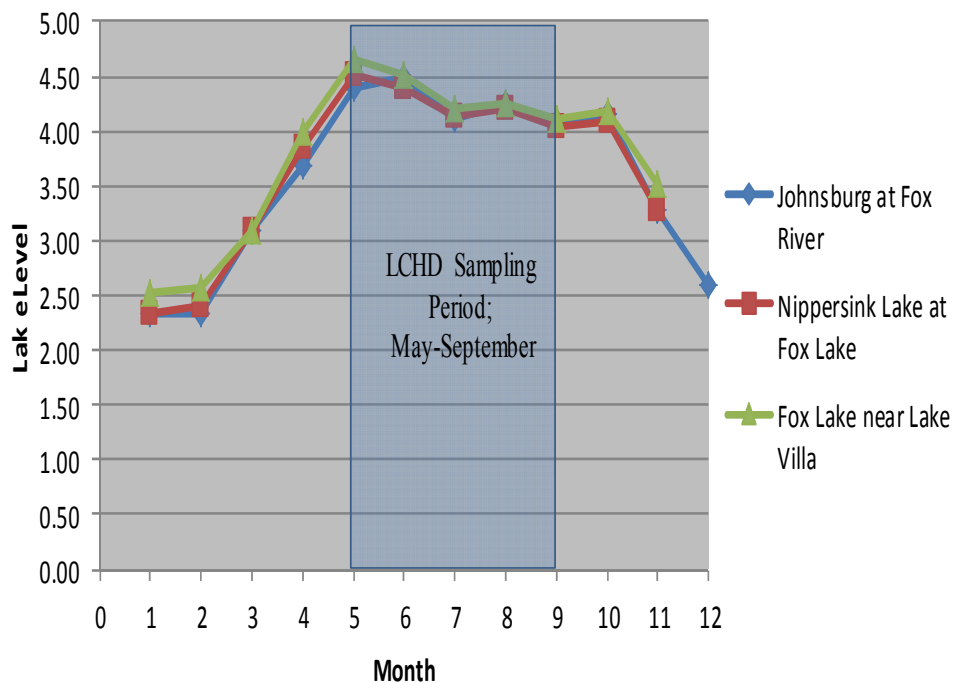
Lakes with stable water levels potentially have less shoreline erosion problems. The Chain O'Lakes water levels are affected by the McHenry Dam, where water levels are required to remain between 3.8-4.2 ft (Figure 8). Climate (rain, snow, and drought events) also play a role in lake level fluctuations.

The main inflow into the Fox Chain lakes is the Fox River with Sequiot, Nippersink, and Squaw creek being other significant tributaries. There is a minimal change in the stream gradient of the Fox River from where it enters Illinois at 732 feet of elevation to when it leaves the Chain O'Lakes at approximately the same elevation. The Stratton Dam in McHenry also helps artificially maintain water these levels and there are three USGS gage stations in the Chain O'Lakes that measure real-time data of water levels. There is minimal lake level fluctuation between these gages and the lakes themselves. During the monitoring season (May - September), lake levels only fluctuated approximately 0.5 ft from 4.51 to 4.04. The lowest lake level occurred in September (4.04) with July also being low (4.13).



Figure 8

2014 Lake Level Data



Left: Lake level data from the three USGS gage states located in the Fox Chain O'Lakes. LCHD-ES sampling occurred during the months of May-September.

| Station | May | June | July | August | September |
|-----------------------------|----------|----------|----------|----------|-----------|
| Johnsburg at Fox River | 4.40 ft. | 4.48 ft. | 4.12 ft. | 4.25 ft. | 4.09 ft. |
| Nippersink Lake at Fox Lake | 4.51 ft. | 4.40 ft. | 4.13 ft. | 4.20 ft. | 4.04 ft. |
| Fox Lake near Lake Villa | 4.65 ft. | 4.51 ft. | 4.20 ft. | 4.26 ft. | 4.12 ft. |

SHORELINE EROSION

Erosion is a natural process primarily caused by water resulting in the loss of material from the shoreline. Disturbed shorelines caused by human activity such as clearing of vegetation and beach rocks, and increasing runoff will accelerate erosion. Eroded materials cause turbidity, sedimentation, nutrients, and pollutants to enter a lake. Excess nutrients are the primary cause of algal blooms and increased aquatic plant growth and once in the lake, sediments, nutrients and pollutants are harder and more expensive to remove.

An in depth shoreline erosion study was not assessed in 2014 for Dunn's Lake. Within the Fox Chain O' Lakes, shorelines typically have vertical seawalls that reflect wave energy. This can also cause scouring of the lake bottom, preventing aquatic plants from establishing near shore. Re-facing a vertical seawall with stone or native plants planted in front of the seawall can absorb wave energy and stabilize lake sediment, minimizing erosion. This will allow aquatic plants to grow in front of the seawall providing habitat for fish and wildlife. Many of the vertical seawalls are failing, and are recommended to be replaced. A permit may be required for any alterations to shoreline in public waters, including the Fox Chain O'Lakes—contact the Illinois DNR.

Additionally, many properties along the lake have manicured lawn and turf up to the lakes edge. Replacing lawn and turf grass at the shoreline with a buffer strip containing native deep-rooted plants will help with erosion and add wildlife habitat. A shoreland buffer helps stabilize the sediment near the lakes edge which prevents soil erosion. The buffer will also filter out pollutants and unwanted nutrients from entering the lake. If these areas are already severely or moderately eroding, a buffer strip of native plants may need to be bolstered with the addition of willow posts, biologs or A-Jacks. Buffer strips should be at least 10-20 feet wide and can include native wildflowers, native grasses, and native wetland plants. Wider buffers may be needed to areas with a greater slope or additional runoff issues. A concern with shoreland buffers is that it may limit access to the lakefront. A smaller mowed path to the shoreline can still allow access to the lake while not interrupting the integrity of the buffer strip. The mowed path for lake access should be kept at least 6 inches tall and not more than 6 feet wide. Buffers do not have to block the view of the lake as there are many colorful, low-growing plants that can be incorporated in the buffer strip and will provide all the benefits of improved water quality.



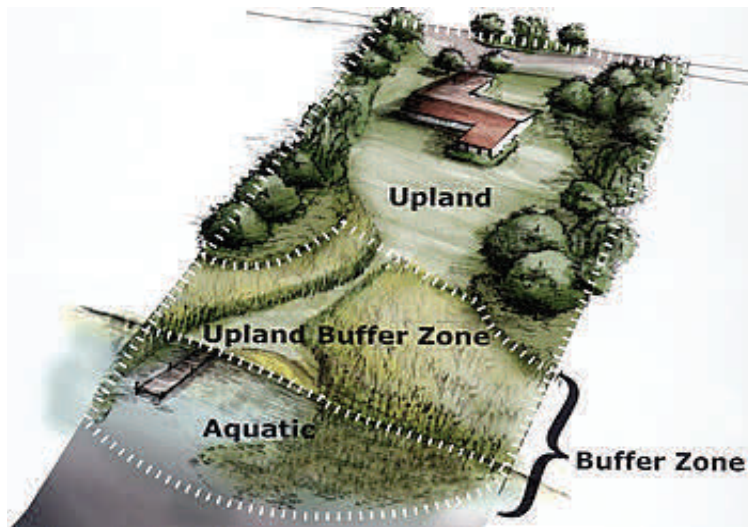
Seawall



Rip rap with a native plant buffer



Buffer strip between upland area and lake edge



“VEGETATIVE BUFFER
ZONES CAN PLAY A KEY
ROLE IN LIMITING
NEGATIVE WATER
QUALITY IMPACTS FROM
DEVELOPED SHORELAND
PROPERTY”

AQUATIC PLANTS

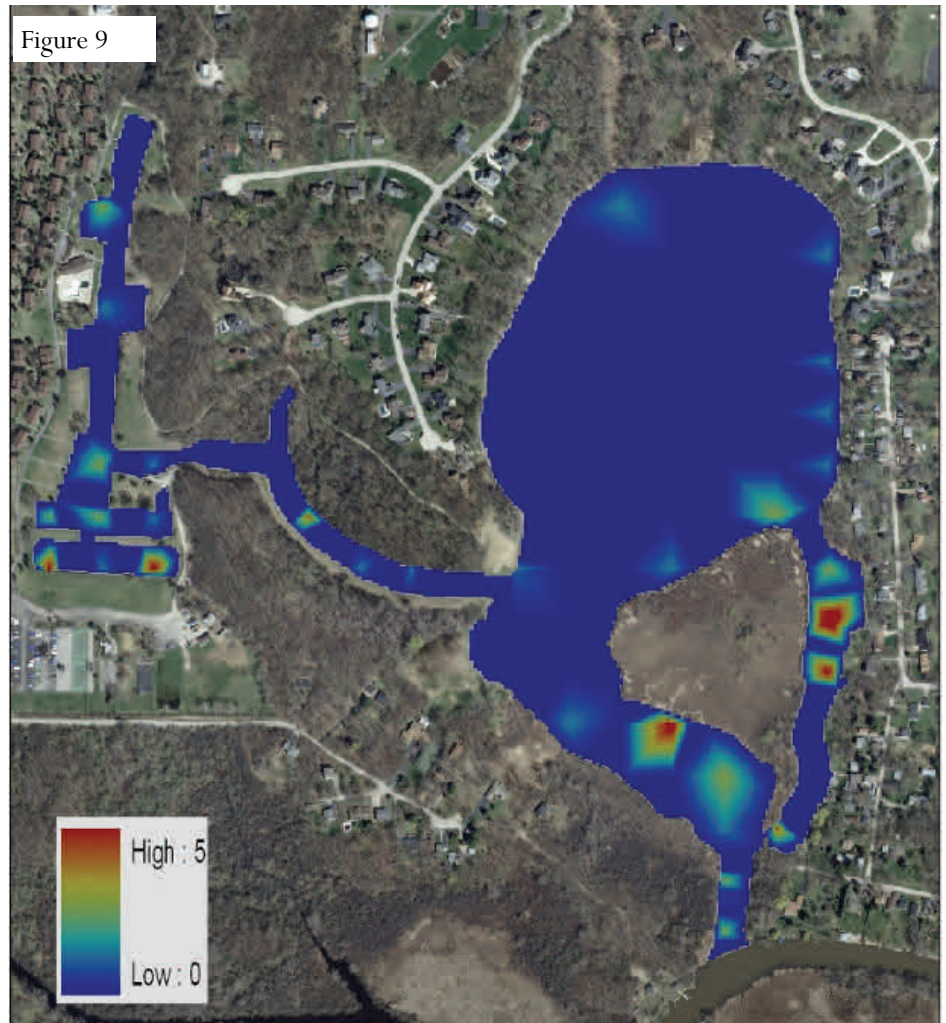
Plants growing in our lakes, ponds, and streams are called macrophytes. These aquatic plants appear in many shapes and sizes. Some have leaves that float on the water surface, while others grow completely underwater. In moderation, aquatic plants are aesthetically pleasing and desirable environmentally. **Their presence is natural and normal in lakes.**

Aquatic plant sampling was conducted on Dunn's Lake in July 2014. There were 79 points generated based on a computer grid system with points 60 meters apart that were sampled. Aquatic plants occurred at 32 of the sites (40.5% total lake coverage frequency) with plants found at a maximum depth of 5.1 feet. There were a total of 9 aquatic plant species found. To maintain a healthy fishery, the Illinois Department of Natural Resources suggests plant coverage of 20% to 40%. Plant coverage on Dunn's lake was 40.5%. Figure 9 represents overall plant rake density on Dunn's Lake.

The most dominant species observed was White Water Lily, found at 34.2% of the sampling sites. Coontail, Duckweed, and Sago pondweed were also common found at 16.5%, 10.1%, and 10.1% of the sites, respectively. A majority of the sampling sites that had plants observed, had a plant density of 1-10%; meaning sites were not densely populated.

An aquatic plant survey was conducted in 2002, but sampling protocol has changed since then, making it hard to compare 2002 to 2014 data. There is an evident reduction of Eurasian Watermilfoil (EWM) in 2014. In 2002, EWM was abundant, occurring at 51% of the sampling sites. In 2014, EWM is still present, but only observed at 5.1% of the sampling sites.

| Rake Density (coverage) | # of Sites | % of Sites |
|------------------------------------|---------------|---------------|
| No Plants | 47 | 59.5 |
| >0-10% | 16 | 20.3 |
| 10-40% | 9 | 11.4 |
| 40-60% | 2 | 2.5 |
| 60-90% | 4 | 5.1 |
| >90% | 1 | 1.3 |
| Total Sites with Plants | 32 | 40.5 |
| Total # of Sites | 79 | 100.0 |



Above: Overall plant rank density for all species on Dunn's Lake for July

AQUATIC PLANTS (CONTINUED)

The diversity and extent of plant populations can be influenced by a variety of factors. Water clarity and depth are the major limiting factors in determining maximum the maximum depth at which aquatic plants will grow. Aquatic plants will not photosynthesize in water depths with less than 1% of the available sunlight. 1% light reached 7 ft. throughout the season, meaning plant could potentially grow at these depths. Plants were found at a maximum depth of 5.1ft. in Dunn's Lake.

Aquatic plants provide many water quality benefits and play an important role in the lakes ecosystem by providing habitat for fish and shelter for aquatic organism. Plants provide oxygen, reduce nutrients such as phosphorus to prevent algae bloom, and help stabilize sediment. A native plant community tends to be diverse and usually does not impede lake activities such as boating, swimming and fishing.

Common Plants found in Dunn's Lake

COONTAIL

CERATOPHYLLUM DEMERSUM



OVERWINTERS AS A EVERGREEN PLANT, IT PROVIDES IMPORTANT HABITAT TO MANY INVERTEBRATES AND FISH.

WHITE WATER LILY

NYMPHAEA TUBEROSA



ROUND, LEAF SLIT ON ONE SIDE ATTACHES TO ROUND STEM WHICH CONTAINS AIR PASSAGEWAYS

SAGO PONDWEED

POTAMOGETON PECTINATUS



HAS NO FLOATING LEAVES. THE STEMS ARE THING, LONG, AND HIHGLY BRANCHING WITH LEAVES VERY THIN AND FILAMENT-LIKE.

AQUATIC PLANTS: WHERE DO THEY GROW?

Littoral Zone— the area that aquatic plants grow in a lake.

Algae— have no true roots, stems, or leaves and range in size from tiny, one- celled organisms to large, multi-celled plant-like organisms.

Submerged Plants— have stems and leaves that grow entirely underwater, although some may also have floating leaves.

Floating-leaf Plants— are often rooted in the lake bottom, but their leaves and flowers lay flat on the water surface.

Emergent Plants— are rooted in the lake bottom, but their leaves and stems extend out of the water.

| Plant Species | % Plant Occurrence |
|------------------------------|--------------------|
| <i>Chara</i> | 2.5 |
| <i>Coontail</i> | 16.5 |
| <i>Duckweed</i> | 10.1 |
| <i>Eurasian Watermilfoil</i> | 5.1 |
| <i>Sago Pondweed</i> | 10.1 |
| <i>Southern Naiad</i> | 1.3 |
| <i>Watermeal</i> | 1.3 |
| <i>Water Stargrass</i> | 1.3 |
| <i>White Water Lily</i> | 34.2 |

Left: A list of plant species found in Dunn's Lake

FLORISTIC QUALITY INDEX

Floristic quality index (FQI) is an assessment tool designed to evaluate how close the flora of an area is that of undisturbed conditions. It can be used to: 1) identify natural areas, 2) compare the quality of different sites or different locations within a single site 3) monitor long-term floristic trends and 4) monitor habitat restoration efforts. Each aquatic plant in a lake is assigned a number between 1 and 10 (10 indicating the plant species most sensitive to disturbance). This is done for every floating and submerged plant species found in the lake. The FQI is calculated by multiplying the average of these numbers by the square root of the number of these plant species found in the lake. A high FQI number indicates that a large number of sensitive, high quality plant species are present in the lake. Non-native species were also included in the FQI calculations for Lake County lakes. The median FQI for Lake County lakes from 2000-2014 was 13.4.

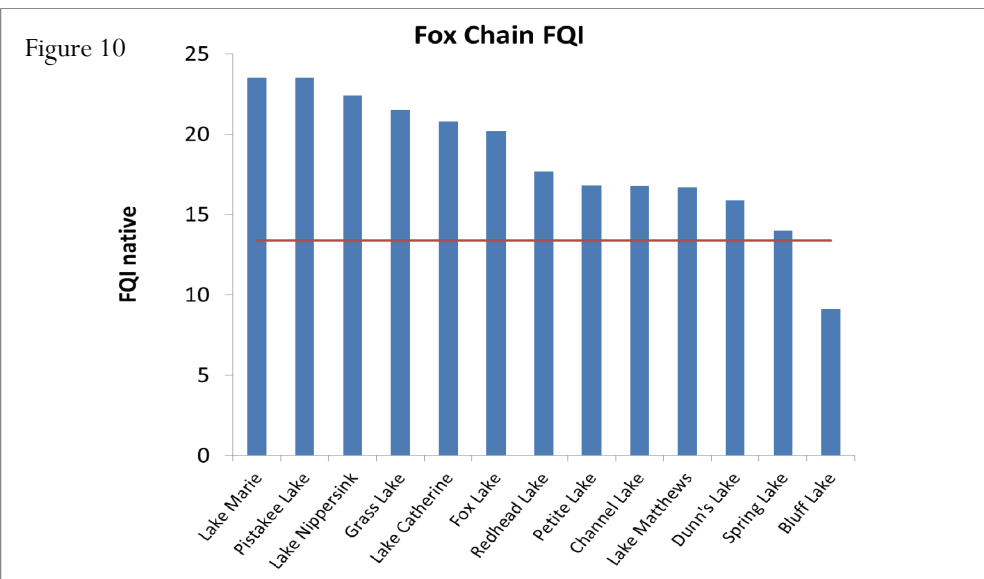
Dunn's Lake had an FQI value of 15.9 ranking it 65 out of 170 lakes in Lake County and 9 plant species were observed. Figure 10 is a graph of the FQI values for the Fox Chain.

**LAKE COUNTY AVERAGE
FQI = 13.4**

**DUNN'S LAKE
FQI = 15.9**

RANK = 65 /170

**AQUATIC PLANTS
SPECIES
OBSERVED = 9**



IN MANY LAKES MACROPHYTES CONTRIBUTE TO THE AESTHETICALLY PLEASING APPEARANCE OF THE SETTING AND ARE ENJOYABLE IN THEIR OWN RIGHT. BUT EVEN MORE IMPORTANT, THEY ARE AN ESSENTIAL ELEMENT IN THE LIFE SYSTEMS OF MOST LAKES.

- Macrophyte leaves and stems provide a habitat or home for small attached plants and animals. Some are microscopic in size and some are larger. These attached organisms are valuable as food for animals higher in the food chain, such as fish and birds.
- Many types of small organisms live in the sediment. There are insects that spend the immature stages of life in the sediments, leaving when they become adults. Decomposing plant life provides part of the food supply for these sediment-dwelling organisms and the emerging insects, in turn, are food for fish.
- The submerged portions of macrophytes provide shelter and cover for small or young fish from larger fish that would feed on them.
- Types of plants that extend above the water can provide cover for waterfowl and their young, and many plants can serve directly as food for certain types of waterfowl.
- Aquatic plants provide many water quality benefits such as sediment stabilization and competition with algae for available nutrients.

AQUATIC PESTICIDES AND AQUATIC PLANT MANAGEMENT

Herbicides are chemical pesticides used to disrupt the growth cycle of plants, and typically work by inhibiting photosynthesis from occurring within the plant. Diquat is a common herbicide used in 2013 treatments to control Eurasian watermilfoil and Curlyleaf pondweed in the Fox Chain. Diquat is a fast-acting herbicide that works by disrupting cell membranes and interfering with photosynthesis. It is non-selective herbicide and will kill a wide variety of plants on contact. It does not move throughout the plants, so it will only kill parts of the plants that it contacts. Following treatment, plants will die within a week. Diquat is not effective in lakes with muddy water because it is so strongly attracted to silt and clay particles in water. Therefore, bottom sediments must not be disturbed during treatments. There are no swimming restrictions for water bodies with Diquat; however water should not be consumed by pets for 1 day following treatment. For more information on Diquat and other chemical treatments, please reference the WIDNR Chemical Fact Sheet attached in the report Appendix D.

It is recommended that a long term Aquatic Plant Management Plan (APMP) be developed for the Fox Chain 'O' Lakes to promote native plant diversity and control exotic invasive species. This would provide parties interested in aquatic plant management with a template to follow and allow decisions on aquatic plant management to be consistent throughout the lakes'. All stakeholders should participate in the development of the plan and include homeowners, recreational users, lake management associations, park districts, townships or any other entity managing aquatic plants on the Fox Chain 'O' Lakes. All aquatic plant management strategies should be investigated and prioritized by the stakeholders. To accomplish this, the plan should address lake usage, sensitive areas and any areas that herbicides are not allowed to come into contact with plants, such as on property owned by landowners who do not wish to have chemicals used on their property. Considerations for herbicide applications include the timing of application. Many pesticides are more effective in cooler water temperatures. Additionally, native plants tend to begin their growth later than some of the invasives. This suggests earlier herbicide applications are recommended.

Systemic herbicides:

absorbed and transported throughout the plant, killing the entire plant including the roots.

Contact herbicides:

only kill the portions of the plant in which the chemical comes into contact with.

Non-selective:

will kill or injure a wide variety of plant species

Selective:

effective on only certain plant species

PERMIT REQUIREMENTS FOR APPLYING PESTICIDES

Dunn's Lake is part of the Fox Chain O'Lakes which are designated as public waters in the state of Illinois. As per the Illinois Department of Natural Resources' Administrative Rule 895, any person, company, or organization that is sponsoring or conducting chemical or non-chemical treatment for the management of aquatic plants in the Fox Chain O'Lakes needs to obtain a Letter of Permission (LOP) from the IDNR. An application for a letter of permission for treatment of plants must be completed—including a map of the proposed area—and submitted to IDNR. The IDNR will then either issue or deny the request within 45 days after the receipt of the complete application. You can find links to the permit application at the Fox Waterway Agency website at www.foxwaterway.com.

New regulations in Illinois require a National Pollutant Discharge Elimination System (NPDES) to apply any type of pesticides over or into waters of the State. Who has to get a permit? According to the language in the permit, anyone who qualifies as an "operator", which is defined as: "any person, persons, group, or entity in control over the financing for, or over the decision to perform pest control activities, or applying pesticides that will result in a discharge to waters of the State". Homeowner associations or even individuals may need to get a permit. Regardless of the size of treatment, a permit will be needed. If the treatment area or total annual area exceeds certain thresholds then additional requirements will be required such as a Pesticide Discharge Management Plan and an annual report. Anyone or any group planning to treat Dunn's Lake this year should take into account both of these requirements. Applicators should be aware of this requirement.

**FOR FULL
DETAILS OF THE
RULE SEE:**

**[HTTP: //
WWW.EPA.STATE.IL.US
/WATER/
PERMITS/
PESTICIDE/
INDEX.HTML](http://WWW.EPA.STATE.IL.US/WATER/PERMITS/PESTICIDE/INDEX.HTML)**



FISH

The Illinois Department of Natural Resources continuously monitors the fish populations in the Fox Chain O' Lakes through biennial fish surveys starting in 1954. Typically, between 35-40 fish species are collected during the biennial survey throughout the waterway system. Three fish species have voluntarily become establishes in the Fox Chain O'Lakes including yellow bass (1973), freshwater drum (1992) and gizzard shad (2007). In 2013, fish surveys were conducted in the Fox Chain O'Lakes by day-electroshocking method. 16 fish species were detected during the day of electroshocking on Dunn's Lake. Bluegill was the most abundant fish caught (87 individuals) followed by Large Mouth Bass (25), and Black Crappie (20).

The Fox Chain 'O' Lakes is annually stocked with 243,000 2" walleye fingerlings, 2 million walleye fry, and at least 2000 muskie fingerlings. Sixty-five thousand 4" to 6" largemouth bass fingerlings are stocked every other year. Natural reproduction maintains all other species.

There is a state owned free boat ramp available at Chain O'Lakes State Park and numerous other private (for fee) launches available throughout the waterway system. Fishing boat, motor, canoe/kayak rentals along with live bait, tackle, ice and food are available at concessions at Chain O'Lakes State Park and the McHenry Dam. There are also boat rentals, restaurants, bait/tackle, and guide services available from private vendors in the area. There are no fish cleaning facilities in the State Park or the McHenry Dam. For more information on fish in the Fox Chain, refer to the Fox Chain O Lakes Fisheries Status Summary by the Illinois Department of Natural Resources.

| Species | Count |
|-----------------|-------|
| Black Crappie | 20 |
| Bluegill | 87 |
| Carp | 11 |
| Channel Catfish | 1 |
| Emerald Shiner | 2 |
| Freshwater Drum | 1 |
| Golden Shiner | 17 |
| Gizzard Shad | 6 |
| Largemouth Bass | 25 |
| Log perch | 2 |
| Spottail Shiner | 1 |
| Quillback | 1 |
| White Bass | 4 |
| White Crappie | 9 |
| White Sucker | 3 |
| Yellow Bass | 6 |

FISHING REGULATIONS

The following fishing regulations Includes the Fox River from the Illinois State line to the Algonquin Dam, which includes the Fox Chain and Dunn's Lake. See the current Illinois Fishing Information booklet or IFISHILLINOIS website <http://www.ifishillinois.org/> for specific details.

| Species | Daily Creel Limit | Minimum Length Limit |
|---|-------------------|---|
| Largemouth Bass and Smallmouth Bass | 6 | 14" |
| (No more than 3 fish can be smallmouth bass, smallmouth must be released immediately between April 1 to June 15, no possession) | | |
| Walleye | 4 | 14" to 18" (18" to 24" protected slot limit, no possession) only 1 fish can be >24" |
| Muskie | 1 | 48" |
| Northern Pike | 3 | 24" |

AQUATIC INVASIVE SPECIES

Aquatic invasive species (AIS) are species that cause economic or environmental harm, or harm to human health. Illinois has a number of invasive species with the most common including: common carp, grass carp, and zebra mussels. The most common aquatic exotic plants include Curlyleaf Pondweed and Eurasian Watermilfoil. Water recreation is a main transport of AIS, as these species can get transported from boats or trailers and then introduced into the water. Invasive species usually outcompete habitat of native species and are more tolerant to variations in water quality giving them an advantage to thrive.

ZEBRA MUSSELS (*Dreissena polymorpha*)



Image from MNDNR

Zebra mussels are small, fingernail-sized mollusks originally native to eastern Europe and western Asia. Zebra mussels were most likely introduced to North America in 1985 or 1986 by ballast water of ships that traveled across the Atlantic and emptied their ballast in the Great Lakes ports. Zebra mussels spread by attaching to boats, nets, docks, swim platforms, boat lifts, and can be moved on any of these objects. They also can attach to aquatic plants which are often transported accidentally when plant material gets stuck on boats and boat parts. Microscopic larvae

(called veligers) can also be carried in water contained in bait buckets, bilges, or any other water removed from an infested lake.

Female zebra mussels can lay up to a million eggs each summer, typically when waters reach around 50°F and spawning peaks at water temperatures around 68°F. A fertilized egg develops into a tiny, free-swimming larvae called a veliger. Veligers are suspended in the water column for 1 to 5 weeks and then begin to sink and search for a stable surface to live, grow and reproduce. This is a unique characteristic of zebra mussels because typically freshwater mussels do not attach to surfaces. Currently, 35 inland lakes in Lake County are known to be infested with the zebra mussel including the Fox Chain O'Lakes, which first documented zebra mussels in 1998. There has appeared to be a die off of Zebra Mussels in the Fox Chain the most recent years, with less being observed.

Zebra mussels are filter feeders feeding on algae/phytoplankton and zooplankton that they obtain by filtering water. One zebra mussel can filter about one quart of water per day, and large colonies can filter a significant amount of water that can remove food resources for other aquatic organisms. Zebra mussels can increase competition for these food sources affecting fish population. Since zebra mussels are plankton feeders, there is often an increase in water clarity and decrease in TP concentrations after an infestation. There is also a concern that zebra mussels may increase blue-green algae as they selectively filter out other plankton species, leaving blue-greens more abundant. Zebra mussels impact recreational lake users by attaching to boat hulls and motors—causing inconvenience for boaters. They are also very sharp and can cut bare feet, as well as dead mussels can have an unpleasant odor affecting swimming and beach areas.

Individuals and homeowner associations can monitor for zebra mussels by immersing a hard substrate (such as a concrete block) in several different places in the lake including boat launches. It is important to monitor several different locations because zebra mussel population may be concentrated in one area of the lake before spreading to the rest. Check the blocks throughout the summer and fall for attached adult mussels. You can also check submerged equipment such as docks and buoys when you remove them for winter storage.

WHAT CAN YOU DO TO HELP PREVENT AIS?



- Clean all visible aquatic plants, zebra mussels, and other invasive species from watercraft, trailers, and water-related equipment before leaving any water access or shoreland.
- Drain water-related equipment (boat, ballast, tanks, portable bait containers, motors) and drain bilge, livewell and baitwell by removing drain plugs before leaving a water access or shoreline property. Keep drain plugs out and water draining devices open while transporting watercraft.
- Dispose of unwanted (including minnows, leeches, and worms) in the trash.
- Educate yourself and others on exotic species. Learn to identify invasive exotic species and report new species if you come across them.

AQUATIC INVASIVE SPECIES (CONTINUED)

CURLYLEAF PONDWEED (*Potamogeton crispus*)

Curlyleaf pondweed (CLP) is an invasive aquatic perennial that is native to Eurasia, Africa, and Australia. It was accidentally introduced to the United States water in the mid-1880's by hobbyists who use it as an aquarium plant.

CLP is a submersed aquatic plant. Curlyleaf pondweed is identifiable by its entire leaves with a prominent midvein and curly toothed edge which alternate along the stem of the plant. CLP has a unique life cycle. Unlike our native pondweeds, it begins growing in the early spring. The vegetative part of the plant dies back completely in early summer and only seeds and turions remain over summer. The turions (which are the main source of reproduction in CLP) sprout in fall, and are rapidly able to elongate in spring after ice melts as temperatures reach 5°C. CLP becomes invasive in some areas because of its adaptations for low light tolerance and low water temperatures which allow the plant to get a head start and outcompete native plants in the spring. In mid summer, when most aquatic plants are growing, CLP plants are dying off. Plant die-offs may result in critical loss of dissolved oxygen.

Large populations of CLP also can cause changes in nutrient availability. In midsummer, CLP plants usually die back which is typically followed by an increase in phosphorus availability that may fuel nuisance algal blooms. CLP can form dense mats that may interfere with boating and other recreational uses. It can also displace native aquatic plants. The most important action that you can take to limit the spread of curlyleaf and other non-native aquatic plants is remove all vegetation from your watercraft before you move it from one body of water to another. Curlyleaf pondweed was not detected in Dunn's Lake in our 2014 sample, but its occurrence and abundance may be an underestimate due to the timing of the survey in July, after most CLP has died off.

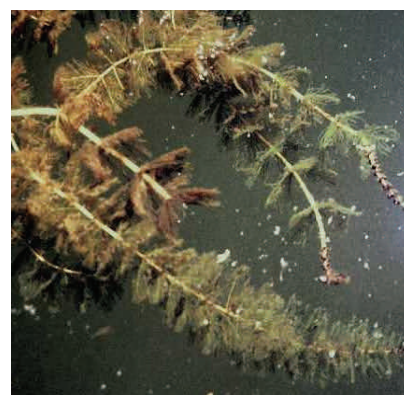


Source: Vic Ramey, UFL
Center for Aquatic and Invasive Plants

EURASIAN WATERMILFOIL (*MYRIOPHYLLUM SPICATUM*)

Eurasian Watermilfoil (EWM) is an invasive, submersed aquatic plant accidentally introduced in the 1940s to North America from Europe from the aquarium trade. EWM can form thick underwater stands of tangled stems and mats of vegetation at the water's surface, which can interfere with water recreation including boating, fishing, and swimming. The plant's floating canopy can also crowd out native plant species.

EWM can reproduce through stem fragmentation and runners meaning a single segment of stem and leaves can take root and form an entire new colony. Removing native vegetation allows for EWM to overtake a lake. EWM can have a difficult time becoming established in lakes with well established populations of native plants. EWM can be controlled using aquatically approved herbicides, mechanical (i.e. harvester or cutter) methods, or biological controls (i.e. weevil). In the Fox Chain O'Lakes, a Letter Of Permission (LOP) from the IDNR is required for any aquatic plant management (see Pesticides section). Aquatic management methods for EWM that cause as little damage to native aquatic plants as possible are encouraged and early season treatments will have the least impact on native populations. EWM was detected in Dunn's Lake in 2014 at 5.1% of the sampling sites. In the Fox Chain O'Lakes, 5 lakes were determined to have a EWM as a dominant member based on the 2014 plant surveys and those lakes include: Bluff, Matthews, Marie, Petite, and Pistakee. EWM abundance seems to fluctuate from year to year which can be attributed to a number of factors including weather patterns and herbicide applications.



AQUATIC INVASIVE SPECIES (CONTINUED)

CARP (CYPRINUS CARPIO)



Carp are considered to be one of the most damaging invasive fish species. Originally introduced to the Midwest waters in the 1800's as a food fish, carp can now be found in 48 States. In the U.S., the common carp is more abundant in manmade impoundments, lakes, and turbid sluggish streams and less abundant in clear waters or streams with a high gradient. They are also highly tolerant of poor water quality.

The common carp has a dark copper-gold back with sides that are lighter, a yellowish belly and olive fins. They have 2 pairs of short barbels on their upper lip and their dorsal and anal fins have a leading spine that are serrated. They spawn from early spring to late summer in water ranging from 15 – 28 C and prefer freshly flooded vegetation as spawning substrate. They prefer to spawn in shallow weedy areas in groups consisting of one female and several males. A single female can produce up to 100,000-500,000 which hatch in 5-8 days. The spawning ritual involves a lot of thrashing in shallow water contributing to turbidity problems. Many eggs succumb to predation, fungus, and bacteria.

Carp are omnivorous and feed over soft bottom substrate where they suck up silt and filter out crustaceans, insect larvae and other desirable food items. Carp are very active when feeding and can be observed around shallow areas where they uproot plants which increases turbidity and nutrient concentrations. Increase in nutrients causes algal blooms and reduction in light penetration that impacts aquatic plants. This can be particularly a problem in shallow lakes, such as Redhead where nutrients can easily cycle throughout the water column.

The carp population on the Fox Chain O' Lakes is made up of 2-3 year classes. The average size of the carp in 2013 for all the lakes was 23.4 inches and weighing 6.25 lbs. The Chain has a healthy population of predator fish such as bass, walleye, catfish and musky that feed on the juvenile carp.

Carp spawning and feeding can both cause increase in turbidity, especially in shallow waters where they uproot plants, and resuspend bottom sediments



Actions you take as a responsible boater are critical in preventing the spread of invasive species in Lake County. Remember, before leaving a lake or river:

- ◆ INSPECT and REMOVE all aquatic plants and animals
- ◆ DRAIN water from motors, live wells, and bait containers
- ◆ DISPOSE of unwanted live bait on land
- ◆ RINSE your boat and equipment with hot (104°F) high pressure tap water or
- ◆ DRY your boat and equipment for at least 5 days

AQUATIC INVASIVE SPECIES (CONTINUED)

AMERICAN GIZZARD SHAD (*Dorosoma cepedianum*, NATIVE)

Gizzard shad are native to central and eastern United States mainly in warm low gradient rivers and streams as well as reservoirs, lakes and ponds. Shad are filter feeders; they prefer warm nutrient rich waters. Their range is temperature limited. Die offs usually occur when the water temperature drops below 37°F. The Illinois DNR collected its first sample of gizzard shad in the Fox Chain O' Lakes in 2007. These shad migrated up the Fox River over fish ladders and dams in order to make it to the Chain. Lakes that receive flood waters from the Des Plaines river can also have them.



While most shad live for 3-5 years, some have been documented to live past 10 years. They reach maturity in 2-3 years and females can produce 40,000 to 450,000 eggs. Spawning takes place during the middle of spring to early summer and usually occurs in the evening. The preferred spawning temperature is between 60°F and 70°F. Male and female shad congregate along the shallow sandy or gravel areas where eggs are released and fertilized. Once the eggs hatch they are on their own since there is no parental care from the parents. The success of the shad fry correlates with the abundance of zooplankton along with stable water level and warmer temperatures. Drastic changes in water level and temperature can decrease the survival rate of the fry. Once they reach the juvenile stage, they grow rapidly. Gizzard shad feed on organic detritus associated with sediments by and also on phytoplankton and zooplankton. At this stage they develop a gizzard and begin filter feeding for food. Sediment and sand are also ingested by the gizzard shad that helps it to digest food in its muscular gizzard; this is where the fish got its name.



Fishermen on the Fox Chain O' Lakes have been seeing large schools of shad swimming in the shallow weedy bays. Gizzard shad provide an abundant food source for bass and walleye, but they may compete with bluegill, crappies and other young of the year game-fish for food. Shad have rapid growth rates, often growing to 5.5 inches in length during their first year. This provides a smaller window of opportunity for bass and walleyes which are gape limited and can only feed effectively on shad up to 6". Fortunately, the Chain has a healthy population of muskies, which are capable of feeding on adult shad. Muskies have benefited from this new food source which is not only abundant but it's easier for them to catch than bluegills and perch.

Gizzard shad can alter the size and density structure of a fishery. They may stunt the bluegill population through common food competition or by reducing the predation pressure. Bass may grow larger due to having more food available for them to eat but their fry may have to compete for food. Gizzard shad also can affect water quality of a lake. Since they are filter feeders, gizzard shad can bring an increase in water clarity in lakes, but they can also impact nutrient dynamics. Gizzard shad have been shown to transfer large quantities of nutrients from benthic (bottom-lake) habitats via sediment feeding and subsequent excretion. At this point it is hard to predict what the overall outcome of the gizzard shad will be on the fishery in the Fox Chain O' Lakes.

ENVIRONMENTAL SERVICES

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For more information visit us at:

**[http://www.lakecountyiil.gov/
Health/want/
BeachLakeInfo.htm](http://www.lakecountyiil.gov/Health/want/BeachLakeInfo.htm)**

Protecting the quality of our lakes is an increasing concern of Lake County residents. Each lake is a valuable resource that must be properly managed if it is to be enjoyed by future generations. To assist with this endeavor, Population Health Environmental Services provides technical expertise essential to the management and protection of Lake County surface waters.

Environmental Service's goal is to monitor the quality of the county's surface water in order to:

- Maintain or improve water quality and alleviate nuisance conditions
- Promote healthy and safe lake conditions
- Protect and improve ecological diversity

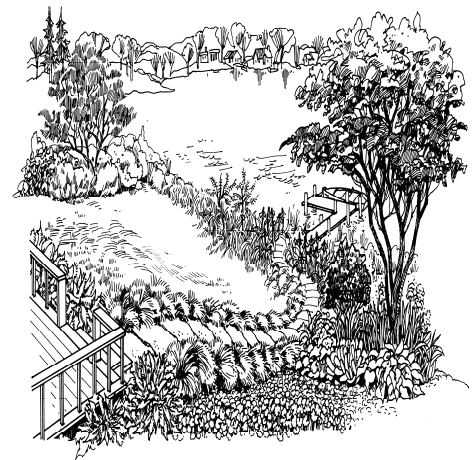
Services provided are either of a technical or educational nature and are provided by a professional staff of scientists to government agencies (county, township and municipal), lake property owners' associations and private individuals on all bodies of water within Lake County.

LAKE RECOMMENDATIONS

Dunn's Lake water quality has declined since the 2002 sampling and is impaired for total phosphorus and total suspended solids.

To improve the overall quality of Dunn's Lake; the ES (Ecological Services) has the following recommendations:

- Participate in the Volunteer Lake Monitoring Program to give baseline and yearly data on water clarity for Dunn's Lake.
- Learn to identify harmful algal blooms (HAB's) and report any to LCHD-ES.
- Consider installing Best Management Practices (BMPs) to minimize phosphorus and sediment runoff into Dunn's Lake. This can include: rain gardens, native buffers between shoreline and homeowner property, and increasing native plantings around the lake.
- Develop an aquatic plant management plan that targets the reduction of invasive species and promotes native plant diversity.
- Install a permanent staff gage to monitor lake level fluctuations.
- Install a sign to educate on AIS species and steps to prevent aquatic hitchhiking.
- The LCHD-ES recommends the creation of an updated bathymetric map. Bathymetric maps provide lake managers with an accurate lake volume that can be used for herbicide application and help anglers find potential fishing spots.



Appendix A:
Tables & Figures

Figure 1: Dunn's sampling points



Figure 2:

Dunn's Lake Plant Rake Density July 2014

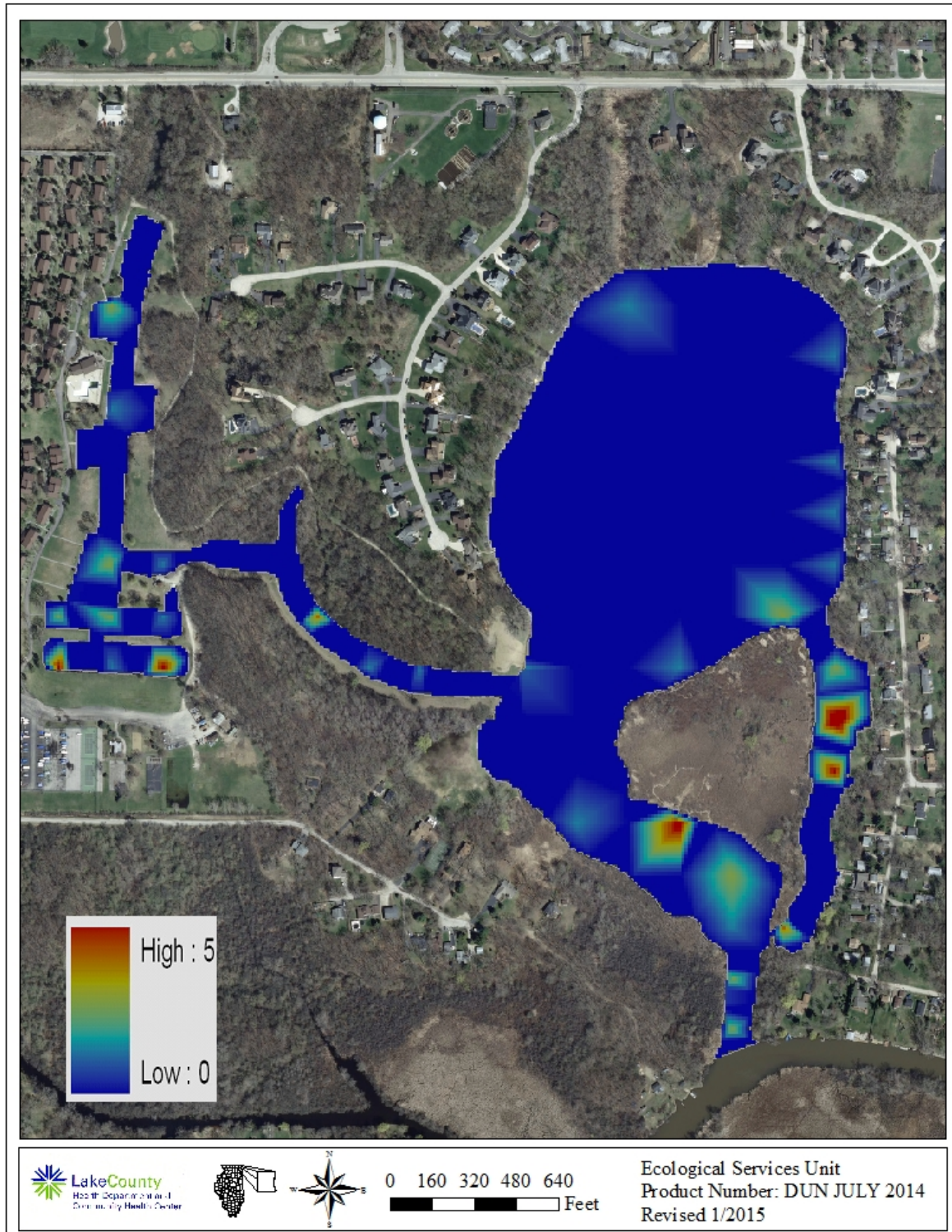


Figure 3:

Dunns Lake Plant Species Diversity, July 2014

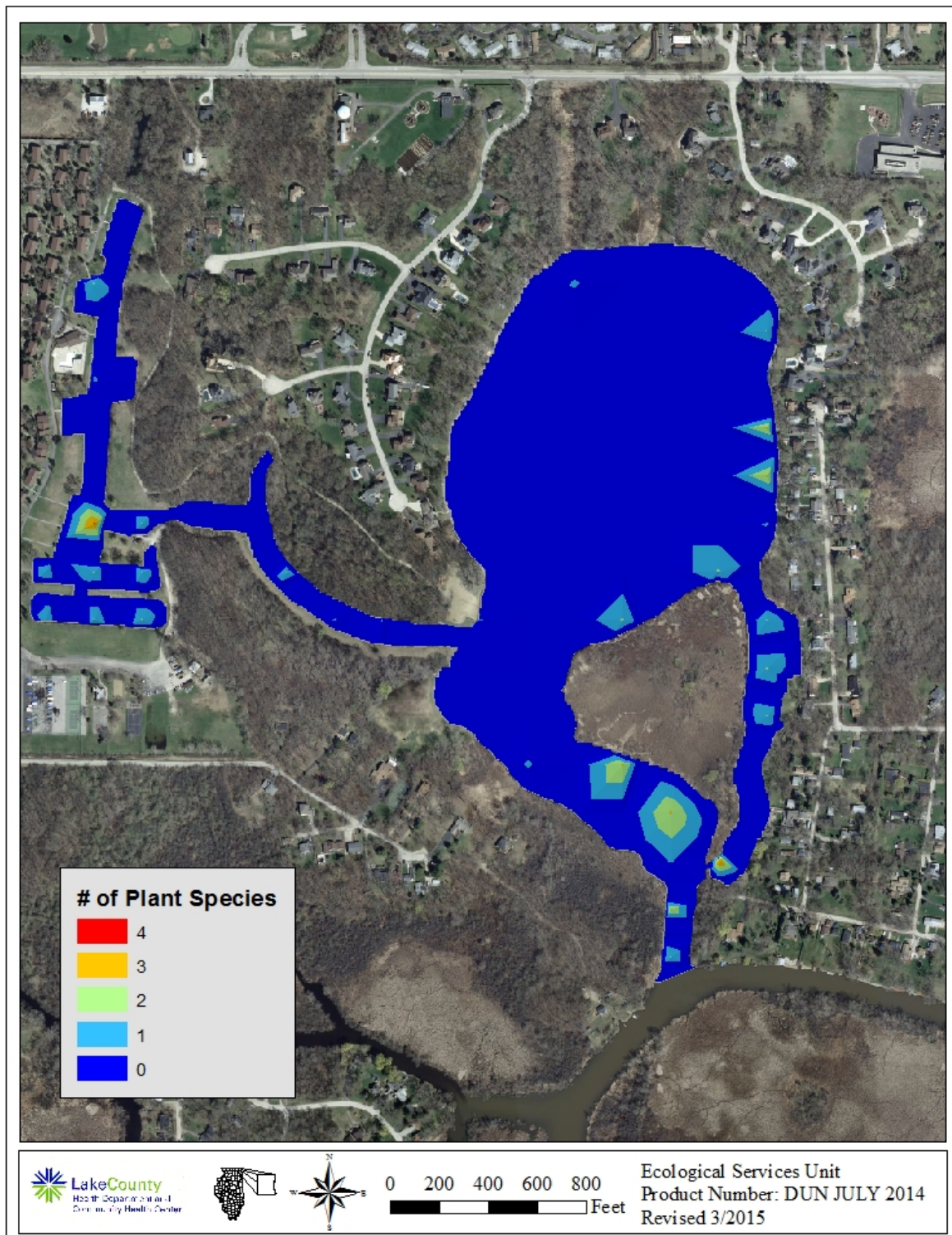


Table 1. 2014 and 2002 Water Quality Data for Dunn's Lake

| Epilimnion | | | | | | | | | | | | | | | | |
|------------|-------|-----|------|--------------------|--------------------|-------|--------------------|-----|-----|------|-----|-----|--------|--------|------|-------|
| 2014 | | | | | | | | | | | | | | | | |
| DATE | DEPTH | ALK | TKN | NH ₃ -N | NO ₃ -N | TP | SRP | Cl- | TDS | TSS | TS | TVS | SECCHI | COND | pH | DO |
| 5/7/2014 | 3 | 190 | 2.35 | <0.1 | 0.423 | 0.118 | <.005 | 117 | 442 | 27 | 519 | 140 | 1.50 | 0.7850 | 8.48 | 12.24 |
| 6/11/2014 | 3 | 218 | 2.39 | 0.466 | 0.335 | 0.074 | <.005 | 121 | 472 | 20 | 552 | 148 | 1.79 | 0.8450 | 8.15 | 9.39 |
| 7/9/2014 | 3 | 197 | 2.01 | <0.1 | <.05 | 0.087 | <.005 | 117 | 451 | 33 | 554 | 172 | 1.10 | 0.8020 | 8.3 | 13.37 |
| 8/13/2014 | 3 | 212 | 3.07 | <0.1 | <.05 | 0.183 | <.005 | 133 | 473 | 60 | 589 | 181 | 0.70 | 0.8460 | 8.01 | 7.91 |
| 9/17/2014 | 3 | 182 | 1.85 | <0.1 | <.05 | 0.071 | <.005 | 132 | 485 | 26 | 545 | 168 | 1.00 | 0.7730 | 8.71 | 15.74 |
| Average | | 200 | 2.33 | .173 ^k | .182 ^k | 0.107 | 0.005 ^k | 124 | 465 | 33.2 | 552 | 162 | 1.22 | 0.8102 | 8.33 | 11.73 |

| 2002 | | | | | | | | | | | | | | | | |
|-----------|-------|-----|------|--------------------|--------------------|-------|-------------------|-----|-------|------|-----|-----|--------|--------|------|-------|
| DATE | DEPTH | ALK | TKN | NH ₃ -N | NO ₃ -N | TP | SRP | Cl- | TDS | TSS | TS | TVS | SECCHI | COND | pH | DO |
| 5/7/2002 | 3 | 242 | 1.78 | 0.307 | 0.464 | 0.082 | <.005 | NA | 442 | 16 | 480 | 166 | 2.00 | 0.7706 | 8.08 | 6.52 |
| 6/11/2002 | 3 | 246 | 1.86 | 0.297 | 0.347 | 0.084 | <.005 | NA | 451 | 16 | 506 | 161 | 2.10 | 0.791 | 8.26 | 8.63 |
| 7/16/2002 | 3 | 197 | 1.82 | <0.1 | <.05 | 0.102 | 0.025 | NA | 390 | 38 | 517 | 197 | 1.15 | 0.7317 | 8.37 | 10.03 |
| 8/13/2002 | 3 | 178 | 2.23 | <0.1 | <.05 | 0.121 | <.005 | NA | 420 | 40.4 | 479 | 165 | 1.15 | 0.7216 | 8.67 | 8.19 |
| 9/10/2002 | 3 | 178 | 1.72 | <0.1 | <.05 | 0.087 | <.005 | NA | 414 | 27 | 474 | 160 | 1.28 | 0.7364 | 8.75 | 10.38 |
| Average | | 208 | 1.88 | .181 ^k | .192 ^k | 0.095 | .009 ^k | NA | 423.4 | 27.5 | 491 | 170 | 1.54 | 0.7503 | 8.43 | 8.75 |

Glossary

ALK = Alkalinity, mg/L CaCO₃
TKN = Total Kjeldahl nitrogen, mg/L
NH₃ = Ammonia nitrogen, mg/L
NO₃ = Nitrate nitrogen, mg/L
TP = Total phosphorus, mg/L
SRP = Soluble reactive phosphorus, mg/L
TDS = Total dissolved solids, mg/L
TSS = Total suspended solids, mg/L
TS = Total solids, mg/L
TVS = Total volatile solids, mg/L
SECCHI = Secchi Disk Depth, Ft.
COND = Conductivity, milliSiemens/cm

k = Denotes that the actual value is known to be less than the value presented
values with a non-detect were considered at the non-detect level for calculating seasonal averages

Table 1. 2014 and 2002 Water Quality Data for Dunn's Lake

| Hypolimnion | | | | | | | | | | | | | | | | |
|----------------|-------|-----|------|--------------------|--------------------|-------|--------------------|-----|-------|------|-----|-----|--------|--------|------|------|
| 2002 | | | | | | | | | | | | | | | | |
| DATE | DEPTH | ALK | TKN | NH ₃ -N | NO ₃ -N | TP | SRP | Cl- | TDS | TSS | TS | TVS | SECCHI | COND | pH | DO |
| 5/7/2002 | 5 | 242 | 1.8 | 0.306 | 0.476 | 0.096 | <.005 | NA | 422 | 17 | 486 | 159 | NA | 0.7703 | 8.08 | 6.59 |
| 6/11/2002 | 5 | 245 | 1.98 | 0.303 | 0.366 | 0.076 | <.005 | NA | 470 | 15 | 504 | 168 | NA | 0.7913 | 8.25 | 8.41 |
| 7/16/2002 | 5 | 199 | 1.6 | <0.1 | <.05 | 0.109 | <.005 | NA | 425 | 38 | 500 | 183 | NA | 0.7385 | 8.11 | 6.91 |
| 8/13/2002 | 5 | 177 | 1.88 | <0.1 | <.05 | 0.118 | <.005 | NA | 408 | 40 | 502 | 186 | NA | 0.7234 | 8.62 | 7.51 |
| 9/10/2002 | 5 | 179 | 1.71 | <0.1 | <.05 | 0.084 | 0.021 | NA | 412 | 29 | 476 | 165 | NA | 0.7372 | 8.7 | 9.62 |
| Average | | 208 | 1.79 | .181 ^k | .198 ^k | 0.097 | .0082 ^k | | 427.4 | 27.8 | 494 | 172 | | 0.7521 | 8.35 | 7.81 |

Glossary

ALK = Alkalinity, mg/L CaCO₃
 TKN = Total Kjeldahl nitrogen, mg/L
 NH₃ = Ammonia nitrogen, mg/L
 NO₃ = Nitrate nitrogen, mg/L
 TP = Total phosphorus, mg/L
 SRP = Soluble reactive phosphorus, mg/L
 TDS = Total dissolved solids, mg/L
 TSS = Total suspended solids, mg/L
 TS = Total solids, mg/L
 TVS = Total volatile solids, mg/L
 SECCHI = Secchi Disk Depth, Ft.
 COND = Conductivity, milliSiemens/cm

k = Denotes that the actual value is known to be less than the value presented
 values with a non-detect were considered at the non-detect level for calculating seasonal averages

*only 2002 had hypolimnion data. Dunn's Lake is a shallow lake and does not thermally stratify. Therefore, there was no need to take a hypolimnion water quality sample in 2014

Dunn's Lake Multparameter Data 2014

| Date MMDDYY | Text Depth feet | Dep25 feet | Temp øC | DO mg/l | DO% Sat | SpCond mS/cm | pH Units | BGA-PC cells | PAR æE/s/mý | Depth of Light Meter feet | % Light Transmission Average | Extinction Coefficient 0.05 |
|----------------|-----------------------|---------------|------------|------------|------------|-----------------|-------------|-----------------|----------------|---------------------------------|------------------------------------|-----------------------------------|
| 5/7/2014 | 0.25 | 0.69 | 14.14 | 11.16 | 108.9 | 782 | 8.55 | 8556 | 2.40 | Surface | | |
| 5/7/2014 | 1 | 1.09 | 14.23 | 12.14 | 118.6 | 784 | 8.48 | 10391 | 16.30 | Surface | 100% | |
| 5/7/2014 | 2 | 1.99 | 14.21 | 12.21 | 119.3 | 784 | 8.49 | 10976 | 15.20 | 0.241 | 93% | 0.29 |
| 5/7/2014 | 3 | 3.05 | 13.63 | 12.24 | 118.1 | 785 | 8.48 | 16310 | 17.50 | 1.299 | 107% | -0.11 |
| 5/7/2014 | 4 | 4.00 | 13.40 | 12.01 | 115.3 | 783 | 8.48 | 16138 | 16.20 | 2.250 | 99% | 0.03 |
| 5/7/2014 | 5 | 5.01 | 13.16 | 11.84 | 113.0 | 784 | 8.48 | 16010 | 15.30 | 3.265 | 94% | 0.02 |
| 5/7/2014 | 6 | 6.02 | 12.96 | 11.89 | 113.0 | 787 | 8.45 | 19193 | 15.60 | 4.266 | 96% | 0.00 |

| Date MMDDYY | Text Depth feet | Dep25 feet | Temp øC | DO mg/l | DO% Sat | SpCond mS/cm | pH Units | BGA-PC cells | PAR æE/s/mý | Depth of Light Meter feet | % Light Transmission Average | Extinction Coefficient 0.72 |
|----------------|-----------------------|---------------|------------|------------|------------|-----------------|-------------|-----------------|----------------|---------------------------------|------------------------------------|-----------------------------------|
| 6/11/2014 | 0.25 | 0.58 | 20.36 | 9.65 | 107.1 | 0.839 | 8.00 | 2264 | 228.60 | Surface | 100% | |
| 6/11/2014 | 1 | 1.00 | 20.37 | 9.60 | 106.7 | 0.844 | 8.12 | 8447 | 107.10 | Surface | 100% | |
| 6/11/2014 | 2 | 2.00 | 20.35 | 9.54 | 105.9 | 0.845 | 8.21 | 10187 | 31.20 | 0.247 | 29% | 4.99 |
| 6/11/2014 | 3 | 3.00 | 20.36 | 9.39 | 104.3 | 0.845 | 8.15 | 11027 | 117.40 | 1.249 | 110% | -1.06 |
| 6/11/2014 | 4 | 4.00 | 20.31 | 9.34 | 103.6 | 0.845 | 8.20 | 8723 | 38.70 | 2.252 | 36% | 0.49 |
| 6/11/2014 | 5 | 5.01 | 20.35 | 9.14 | 101.5 | 0.845 | 8.20 | 8045 | 43.10 | 3.259 | 40% | -0.03 |
| 6/11/2014 | 6 | 6.00 | 20.29 | 9.22 | 102.2 | 0.845 | 8.17 | 6185 | 54.80 | 4.252 | 51% | -0.06 |
| 6/11/2014 | 7 | 6.89 | 20.45 | 8.44 | 93.9 | 0.849 | 7.58 | 31175 | 67.10 | 5.145 | 63% | -0.04 |

Dunn's Lake Multparameter Data 2014

| Date MMDDYY | Text Depth feet | Dep25 feet | Temp øC | DO mg/l | DO% Sat | SpCond mS/cm | pH Units | BGA-PC cells | PAR æE/s/mý | Depth of Light Meter feet | % Light Transmission Average | Extinction Coefficient -0.03 |
|----------------|-----------------------|---------------|------------|------------|------------|-----------------|-------------|-----------------|----------------|---------------------------------|------------------------------------|------------------------------------|
| 7/9/2014 | 0.25 | 0.50 | 25.89 | 13 | 160.3 | 0.804 | 8.41 | 36948 | 6.70 | Surface | 100% | |
| 7/9/2014 | 1 | 1.04 | 25.89 | 13.18 | 162.5 | 0.803 | 8.28 | 38372 | 214.30 | Surface | 100% | |
| 7/9/2014 | 2 | 2.02 | 25.89 | 13.23 | 163.1 | 0.803 | 8.28 | 36340 | 226.30 | 0.27 | 106% | -0.20 |
| 7/9/2014 | 3 | 3.06 | 25.94 | 13.37 | 165.8 | 0.802 | 8.3 | 2040 | 254.20 | 1.31 | 119% | -0.09 |
| 7/9/2014 | 4 | 4.00 | 25.91 | 13.49 | 166.4 | 0.802 | 8.31 | 38621 | 221.80 | 2.25 | 103% | 0.06 |
| 7/9/2014 | 5 | 5.02 | 25.8 | 12.61 | 155.2 | 0.802 | 8.3 | 47371 | 197.60 | 3.27 | 92% | 0.04 |
| 7/9/2014 | 6 | 6.02 | 25.56 | 13.15 | 161.1 | 0.805 | 8.26 | 44874 | 185.30 | 4.27 | 86% | 0.02 |
| 7/9/2014 | 7 | 6.94 | 25.41 | 12.37 | 151.2 | 0.805 | 7.95 | 86889 | 193.5 | 5.19 | 90% | -0.01 |

| Date MMDDYY | Text Depth feet | Dep25 feet | Temp øC | DO mg/l | DO% Sat | SpCond mS/cm | pH Units | BGA-PC | PAR æE/s/mý | Depth of Light Meter feet | % Light Transmission Average | Extinction Coefficient #DIV/0! |
|----------------|-----------------------|---------------|------------|------------|------------|-----------------|-------------|--------|----------------|---------------------------------|------------------------------------|--------------------------------------|
| 8/13/2014 | 0.25 | 0.54 | 22.93 | 8.34 | 96.9 | 0.844 | 8.20 | 2437 | 7.4 | Surface | | |
| 8/13/2014 | 1 | 1.00 | 22.79 | 8.02 | 93.3 | 0.846 | 8.19 | 93671 | 14.0 | Surface | | |
| 8/13/2014 | 2 | 2.00 | 22.77 | 7.96 | 92.6 | 0.847 | 8.01 | 96083 | 174.2 | 0.251 | NA | NA |
| 8/13/2014 | 3 | 3.02 | 22.73 | 7.91 | 91.9 | 0.846 | 8.01 | 103402 | 159.4 | 1.274 | NA | NA |
| 8/13/2014 | 4 | 4.00 | 22.59 | 7.64 | 88.5 | 0.846 | 7.97 | 100304 | 155.5 | 2.253 | NA | NA |
| 8/13/2014 | 5 | 5.02 | 22.63 | 7.50 | 87.0 | 0.846 | 7.97 | 94662 | 150.9 | 3.273 | NA | NA |
| 8/13/2014 | 6 | 5.98 | 22.57 | 7.48 | 86.6 | 0.846 | 7.96 | 98490 | 148.5 | 4.235 | NA | NA |
| 8/13/2014 | 7 | 6.98 | 22.45 | 6.77 | 78.3 | 0.846 | 7.94 | 103274 | 148.9 | 5.233 | NA | NA |

| Date MMDDYY | Text Depth feet | Dep25 feet | Temp øC | DO mg/l | DO% Sat | SpCond mS/cm | pH Units | BGA-PC | PAR æE/s/mý | Depth of Light Meter feet | % Light Transmission | Extinction Coefficient |
|----------------|-----------------------|---------------|------------|------------|------------|-----------------|-------------|--------|----------------|---------------------------------|-------------------------|---------------------------|
| 9/17/2014 | 0.25 | 0.25 | 20.62 | 12.09 | 134.9 | 0.706 | 8.49 | NR | NR | Surface | | |
| 9/17/2014 | 1 | 1 | 17.63 | 12.74 | 133.8 | 0.774 | 8.69 | NR | NR | Surface | | |
| 9/17/2014 | 2 | 2 | 17.61 | 15.59 | 163.7 | 0.773 | 8.70 | NR | NR | 0.25 | NA | NA |
| 9/17/2014 | 3 | 3 | 17.58 | 15.74 | 165.2 | 0.773 | 8.71 | NR | NR | 1.25 | NA | NA |
| 9/17/2014 | 4 | 4 | 17.37 | 14.61 | 152.7 | 0.776 | 8.66 | NR | NR | 2.25 | NA | NA |
| 9/17/2014 | 5 | 5 | 16.62 | 15.06 | 154.9 | 0.773 | 8.61 | NR | NR | 3.25 | NA | NA |
| 9/17/2014 | 6 | 6 | 16.57 | 8.40 | 86.3 | 0.786 | 8.47 | NR | NR | 4.25 | NA | NA |

Lake County average TSI phosphorus (TSIp) ranking 2000-2014.

| RANK | LAKE NAME | TP AVE | TSIp |
|------|---------------------|--------|-------|
| 1 | Lake Carina | 0.0100 | 37.35 |
| 2 | Sterling Lake | 0.0100 | 37.35 |
| 3 | Cedar Lake | 0.0130 | 41.14 |
| 4 | Indpendence Grove | 0.0130 | 41.14 |
| 5 | Lake Zurich | 0.0135 | 41.68 |
| 6 | Druce Lake | 0.0140 | 42.00 |
| 7 | Windward Lake | 0.0160 | 44.13 |
| 8 | Sand Pond (IDNR) | 0.0165 | 44.57 |
| 9 | West Loon | 0.0170 | 45.00 |
| 10 | Pulaski Pond | 0.0180 | 45.83 |
| 11 | Banana Pond | 0.0200 | 47.35 |
| 12 | Gages Lake | 0.0200 | 47.35 |
| 13 | Lake Kathryn | 0.0200 | 47.35 |
| 14 | Lake Minear | 0.0200 | 47.35 |
| 15 | Highland Lake | 0.0202 | 47.49 |
| 16 | Lake Miltmore | 0.0210 | 48.00 |
| 17 | Timber Lake (North) | 0.0210 | 48.05 |
| 18 | Cross Lake | 0.0220 | 48.72 |
| 19 | Dog Training Pond | 0.0220 | 48.72 |
| 20 | Sun Lake | 0.0220 | 48.72 |
| 21 | Deep Lake | 0.0230 | 49.36 |
| 22 | Lake of the Hollow | 0.0230 | 49.36 |
| 23 | Round Lake | 0.0230 | 49.36 |
| 24 | Stone Quarry Lake | 0.0230 | 49.36 |
| 25 | Little Silver Lake | 0.0250 | 50.57 |
| 26 | Bangs Lake | 0.0260 | 51.13 |
| 27 | Lake Leo | 0.0260 | 51.13 |
| 28 | Cranberry Lake | 0.0270 | 51.68 |
| 29 | Dugdale Lake | 0.0270 | 51.68 |
| 30 | Peterson Pond | 0.0270 | 51.68 |
| 31 | Fourth Lake | 0.0360 | 53.00 |
| 32 | Lambs Farm Lake | 0.0310 | 53.67 |
| 33 | Old School Lake | 0.0310 | 53.67 |
| 34 | Grays Lake | 0.0310 | 54.00 |
| 35 | Harvey Lake | 0.0320 | 54.50 |
| 36 | Hendrick Lake | 0.0340 | 55.00 |
| 37 | Honey Lake | 0.0340 | 55.00 |
| 38 | Sand Lake | 0.0380 | 56.00 |
| 39 | Third Lake | 0.0384 | 56.00 |
| 40 | Sullivan Lake | 0.0370 | 56.22 |
| 41 | Ames Pit | 0.0390 | 56.98 |
| 42 | Diamond Lake | 0.0390 | 56.98 |
| 43 | East Loon | 0.0400 | 57.34 |
| 44 | Schreiber Lake | 0.0400 | 57.34 |
| 45 | Waterford Lake | 0.0400 | 57.34 |
| 46 | Hook Lake | 0.0410 | 57.70 |

Lake County average TSI phosphorus (TSIp) ranking 2000-2014.

| RANK | LAKE NAME | TP AVE | TSIp |
|------|---------------------------|--------|-------|
| 47 | Nielsen Pond | 0.0450 | 59.04 |
| 48 | Seven Acre Lake | 0.0460 | 59.36 |
| 49 | Turner Lake | 0.0460 | 59.36 |
| 50 | Willow Lake | 0.0460 | 59.36 |
| 51 | East Meadow Lake | 0.0480 | 59.97 |
| 52 | Lucky Lake | 0.0480 | 59.97 |
| 53 | Old Oak Lake | 0.0490 | 60.27 |
| 54 | College Trail Lake | 0.0500 | 60.56 |
| 55 | Hastings Lake | 0.0520 | 61.13 |
| 56 | Butler Lake | 0.0530 | 61.40 |
| 57 | West Meadow Lake | 0.0530 | 61.40 |
| 58 | Wooster Lake | 0.0530 | 61.40 |
| 59 | Lucy Lake | 0.0550 | 61.94 |
| 60 | Lake Linden | 0.0570 | 62.45 |
| 61 | Lake Christa | 0.0580 | 62.70 |
| 62 | Owens Lake | 0.0580 | 62.70 |
| 63 | Briarcrest Pond | 0.0580 | 63.00 |
| 64 | Lake Barrington | 0.0600 | 63.10 |
| 65 | Redhead Lake | 0.0608 | 63.20 |
| 66 | Lake Lakeland Estates | 0.0620 | 63.66 |
| 67 | Lake Naomi | 0.0620 | 63.66 |
| 68 | Lake Tranquility (S1) | 0.0620 | 63.66 |
| 69 | Lake Catherine | 0.0620 | 63.76 |
| 70 | Liberty Lake | 0.0630 | 63.89 |
| 71 | North Tower Lake | 0.0630 | 63.89 |
| 72 | Werhane Lake | 0.0630 | 63.89 |
| 73 | Countryside Glen Lake | 0.0640 | 64.12 |
| 74 | Davis Lake | 0.0650 | 64.34 |
| 75 | Leisure Lake | 0.0650 | 64.34 |
| 76 | St. Mary's Lake | 0.0670 | 64.78 |
| 77 | Channel Lake | 0.0680 | 64.91 |
| 78 | Buffalo Creek Reservoir 1 | 0.0680 | 65.00 |
| 79 | Mary Lee Lake | 0.0680 | 65.00 |
| 80 | Little Bear Lake | 0.0680 | 65.00 |
| 81 | Timber Lake (South) | 0.0720 | 65.82 |
| 82 | Lake Helen | 0.0720 | 65.82 |
| 83 | Grandwood Park Lake | 0.0720 | 65.82 |
| 84 | Crooked Lake | 0.0710 | 66.00 |
| 85 | ADID 203 | 0.0730 | 66.02 |
| 86 | Broberg Marsh | 0.0780 | 66.97 |
| 87 | Redwing Slough | 0.0822 | 67.73 |
| 88 | Tower Lake | 0.0830 | 67.87 |
| 89 | Countryside Lake | 0.0800 | 68.00 |
| 90 | Lake Nippersink | 0.0800 | 68.00 |
| 91 | Woodland Lake | 0.0800 | 68.00 |

Lake County average TSI phosphorus (TSIp) ranking 2000-2014.

| RANK | LAKE NAME | TP AVE | TSIp |
|------|--------------------------------------|--------|-------|
| 92 | Lake Fairview | 0.0890 | 68.00 |
| 93 | Potomac Lake | 0.0850 | 68.21 |
| 94 | White Lake | 0.0862 | 68.42 |
| 95 | Grand Ave Marsh | 0.0870 | 68.55 |
| 96 | North Churchill Lake | 0.0870 | 68.55 |
| 97 | McDonald Lake 1 | 0.0880 | 68.71 |
| 98 | Pistakee Lake | 0.0880 | 68.71 |
| 99 | Rivershire Pond 2 | 0.0900 | 69.04 |
| 100 | South Churchill Lake | 0.0900 | 69.04 |
| 101 | McGreal Lake | 0.0910 | 69.20 |
| 102 | Lake Charles | 0.0930 | 69.40 |
| 103 | Deer Lake | 0.0940 | 69.66 |
| 104 | Eagle Lake (S1) | 0.0950 | 69.82 |
| 105 | International Mine and Chemical Lake | 0.0950 | 69.82 |
| 106 | Valley Lake | 0.0950 | 69.82 |
| 107 | Buffalo Creek Reservoir 2 | 0.0960 | 69.97 |
| 108 | Fish Lake | 0.0960 | 69.97 |
| 109 | Lochanora Lake | 0.0960 | 69.97 |
| 110 | Big Bear Lake | 0.0960 | 69.97 |
| 111 | Fox Lake | 0.1000 | 70.52 |
| 112 | Nippersink Lake - LCFP | 0.1000 | 70.56 |
| 113 | Sylvan Lake | 0.1000 | 70.56 |
| 114 | Petite Lake | 0.1020 | 70.84 |
| 115 | Longview Meadow Lake | 0.1020 | 70.84 |
| 116 | Lake Marie | 0.1030 | 70.93 |
| 117 | Dunn's Lake | 0.1070 | 71.53 |
| 118 | Lake Forest Pond | 0.1070 | 71.53 |
| 119 | Long Lake | 0.1070 | 71.53 |
| 120 | Grass Lake | 0.1090 | 71.77 |
| 121 | Spring Lake | 0.1100 | 71.93 |
| 122 | Kemper 2 | 0.1100 | 71.93 |
| 123 | Bittersweet Golf Course #13 | 0.1100 | 71.93 |
| 124 | Bluff Lake | 0.1120 | 72.00 |
| 125 | Middlefork Savannah Outlet 1 | 0.1120 | 72.00 |
| 126 | Osprey Lake | 0.1110 | 72.06 |
| 127 | Bresen Lake | 0.1130 | 72.32 |
| 128 | Round Lake Marsh North | 0.1130 | 72.32 |
| 129 | Deer Lake Meadow Lake | 0.1160 | 72.70 |
| 130 | Lake Matthews | 0.1180 | 72.94 |
| 131 | Taylor Lake | 0.1180 | 72.94 |
| 132 | Island Lake | 0.1210 | 73.00 |

Lake County average TSI phosphorus (TSIp) ranking 2000-2014.

| RANK | LAKE NAME | TP AVE | TSIp |
|------|-------------------------------|---------------|-------------|
| 133 | Columbus Park Lake | 0.1230 | 73.54 |
| 134 | Echo Lake | 0.1250 | 73.77 |
| 135 | Lake Holloway | 0.1320 | 74.56 |
| 136 | Antioch Lake | 0.1450 | 75.91 |
| 137 | Lakewood Marsh | 0.1510 | 76.50 |
| 138 | Pond-A-Rudy | 0.1510 | 76.50 |
| 139 | Forest Lake | 0.1540 | 76.78 |
| 140 | Slocum Lake | 0.1500 | 77.00 |
| 141 | Middlefork Savannah Outlet 2 | 0.1590 | 77.00 |
| 142 | Grassy Lake | 0.1610 | 77.42 |
| 143 | Salem Lake | 0.1650 | 77.78 |
| 144 | Half Day Pit | 0.1690 | 78.12 |
| 145 | Lake Eleanor | 0.1810 | 79.11 |
| 146 | Lake Farmington | 0.1850 | 79.43 |
| 147 | Lake Louise | 0.1850 | 79.43 |
| 148 | ADID 127 | 0.1890 | 79.74 |
| 149 | Lake Napa Suwe | 0.1940 | 80.00 |
| 150 | Patski Pond | 0.1970 | 80.33 |
| 151 | Dog Bone Lake | 0.1990 | 80.48 |
| 152 | Summerhill Estates Lake | 0.1990 | 80.48 |
| 153 | Redwing Marsh | 0.2070 | 81.05 |
| 154 | Stockholm Lake | 0.2082 | 81.13 |
| 155 | Bishop Lake | 0.2160 | 81.66 |
| 156 | Ozaukee Lake | 0.2200 | 81.93 |
| 157 | Kemper 1 | 0.2220 | 82.08 |
| 158 | Hidden Lake | 0.2240 | 82.19 |
| 159 | McDonald Lake 2 | 0.2250 | 82.28 |
| 160 | Fischer Lake | 0.2280 | 82.44 |
| 161 | Oak Hills Lake | 0.2790 | 85.35 |
| 162 | Loch Lomond | 0.2950 | 86.16 |
| 163 | Heron Pond | 0.2990 | 86.35 |
| 164 | Rollins Savannah 1 | 0.3070 | 87.00 |
| 165 | Fairfield Marsh | 0.3260 | 87.60 |
| 166 | ADID 182 | 0.3280 | 87.69 |
| 167 | Slough Lake | 0.3860 | 90.03 |
| 168 | Manning's Slough | 0.3820 | 90.22 |
| 169 | Rasmussen Lake | 0.4860 | 93.36 |
| 170 | Albert Lake, Site II, outflow | 0.4950 | 93.67 |
| 171 | Flint Lake Outlet | 0.5000 | 93.76 |
| 172 | Rollins Savannah 2 | 0.5870 | 96.00 |
| 173 | Almond Marsh | 1.9510 | 113.00 |
| | <i>Average</i> | <i>0.1145</i> | <i>66.2</i> |

Lake County average Floristic Quality Index (FQI) ranking 2000-2014.

| RANK | LAKE NAME | FQI (w/A) | FQI (native) |
|------|-----------------------------|-----------|--------------|
| 1 | Cedar Lake | 37.4 | 38.9 |
| 2 | East Loon Lake | 34.7 | 36.1 |
| 3 | Cranberry Lake | 29.7 | 29.7 |
| 4 | Deep Lake | 29.7 | 31.2 |
| 5 | Little Silver Lake | 29.6 | 31.6 |
| 6 | Round Lake Marsh North | 29.1 | 29.9 |
| 7 | West Loon Lake | 27.1 | 29.5 |
| 8 | Sullivan Lake | 26.9 | 28.5 |
| 9 | Bangs Lake | 26.2 | 27.8 |
| 10 | Third Lake | 25.1 | 22.5 |
| 11 | Fourth Lake | 24.7 | 27.1 |
| 12 | Independence Grove | 24.6 | 27.5 |
| 13 | Sterling Lake | 24.5 | 26.9 |
| 14 | Sun Lake | 24.3 | 26.1 |
| 15 | Lake Zurich | 24.3 | 27.1 |
| 16 | Redwing Slough | 24.0 | 25.8 |
| 17 | Schreiber Lake | 23.9 | 24.8 |
| 18 | Lakewood Marsh | 23.8 | 24.7 |
| 19 | Deer Lake | 23.5 | 24.4 |
| 20 | Round Lake | 23.5 | 25.9 |
| 21 | Pistakee Lake | 23.5 | 25.2 |
| 22 | Lake Marie | 23.5 | 25.2 |
| 23 | Honey Lake | 23.3 | 25.1 |
| 24 | Lake of the Hollow | 23.0 | 24.8 |
| 25 | Cross Lake | 22.4 | 24.2 |
| 26 | Nippersink Lake (Fox Chain) | 22.4 | 23.2 |
| 27 | Countryside Glen Lake | 21.9 | 22.8 |
| 28 | Grass Lake | 21.5 | 22.2 |
| 29 | Davis Lake | 21.4 | 21.4 |
| 30 | Butler Lake | 21.4 | 23.1 |
| 31 | Lake Barrington | 21.2 | 21.2 |
| 32 | Duck Lake | 21.1 | 22.9 |
| 33 | Timber Lake (North) | 20.9 | 23.4 |
| 34 | Lake Catherine | 20.8 | 21.8 |
| 35 | ADID 203 | 20.5 | 20.5 |
| 36 | Broberg Marsh | 20.5 | 21.4 |
| 37 | McGreal Lake | 20.2 | 22.1 |
| 38 | Fox Lake | 20.2 | 21.2 |
| 39 | Lake Kathryn | 19.6 | 20.7 |
| 40 | Fish Lake | 19.3 | 21.2 |
| 41 | Druce Lake | 19.1 | 21.8 |
| 42 | Turner Lake | 18.6 | 21.2 |
| 43 | Wooster Lake | 18.5 | 20.2 |
| 44 | Salem Lake | 18.5 | 20.2 |
| 45 | Lake Helen | 18.0 | 18.0 |
| 46 | Old Oak Lake | 18.0 | 19.1 |
| 47 | Potomac Lake | 17.8 | 17.8 |
| 48 | Redhead Lake | 17.7 | 18.7 |
| 49 | Long Lake | 17.7 | 15.8 |
| 50 | Hendrick Lake | 17.7 | 17.7 |
| 51 | Rollins Savannah 2 | 17.7 | 17.7 |
| 52 | Grandwood Park Lake | 17.2 | 19.0 |
| 53 | Seven Acre Lake | 17.0 | 15.5 |
| 54 | Lake Miltmore | 16.8 | 18.7 |
| 55 | Petite Lake | 16.8 | 18.7 |
| 56 | Channel Lake | 16.8 | 18.7 |
| 57 | McDonald Lake 1 | 16.7 | 17.7 |

Lake County average Floristic Quality Index (FQI) ranking 2000-2014.

| RANK | LAKE NAME | FQI (w/A) | FQI (native) |
|------|---------------------------|-----------|--------------|
| 58 | Highland Lake | 16.7 | 18.9 |
| 59 | Bresen Lake | 16.6 | 17.8 |
| 60 | Almond Marsh | 16.3 | 17.3 |
| 61 | Owens Lake | 16.3 | 17.3 |
| 62 | Windward Lake | 16.3 | 17.6 |
| 63 | Grays Lake | 16.1 | 16.1 |
| 64 | White Lake | 16.0 | 17.0 |
| 65 | Dunns Lake | 15.9 | 17.0 |
| 66 | Dog Bone Lake | 15.7 | 15.7 |
| 67 | Osprey Lake | 15.5 | 17.3 |
| 68 | Heron Pond | 15.1 | 15.1 |
| 69 | North Churchill Lake | 15.0 | 15.0 |
| 70 | Hastings Lake | 15.0 | 17.0 |
| 71 | Lake Tranquility (S1) | 15.0 | 17.0 |
| 72 | Forest Lake | 14.8 | 15.9 |
| 73 | Dog Training Pond | 14.7 | 15.9 |
| 74 | Grand Ave Marsh | 14.3 | 16.3 |
| 75 | Nippersink Lake | 14.3 | 16.3 |
| 76 | Taylor Lake | 14.3 | 16.3 |
| 77 | Manning's Slough | 14.1 | 16.3 |
| 78 | Tower Lake | 14.0 | 14.0 |
| 79 | Dugdale Lake | 14.0 | 15.1 |
| 80 | Eagle Lake (S1) | 14.0 | 15.1 |
| 81 | Crooked Lake | 14.0 | 16.0 |
| 82 | Spring Lake | 14.0 | 15.2 |
| 83 | Lake Matthews | 13.9 | 15.5 |
| 84 | Longview Meadow Lake | 13.9 | 13.9 |
| 85 | Bishop Lake | 13.4 | 15.0 |
| 86 | Ames Pit | 13.4 | 15.5 |
| 87 | Mary Lee Lake | 13.1 | 15.1 |
| 88 | Old School Lake | 13.1 | 15.1 |
| 89 | Summerhill Estates Lake | 12.7 | 13.9 |
| 90 | Buffalo Creek Reservoir 1 | 12.5 | 11.4 |
| 91 | Buffalo Creek Reservoir 2 | 12.5 | 11.4 |
| 92 | McDonald Lake 2 | 12.5 | 12.5 |
| 93 | Rollins Savannah 1 | 12.5 | 12.5 |
| 94 | Stone Quarry Lake | 12.5 | 12.5 |
| 95 | Kemper Lake 1 | 12.2 | 13.4 |
| 96 | Pond-A-Rudy | 12.1 | 12.1 |
| 97 | Stockholm Lake | 12.1 | 13.5 |
| 98 | Lake Carina | 12.1 | 14.3 |
| 99 | Lake Leo | 12.1 | 14.3 |
| 100 | Lambs Farm Lake | 12.1 | 14.3 |
| 101 | Grassy Lake | 12.0 | 12.0 |
| 102 | Flint Lake Outlet | 11.8 | 13.0 |
| 103 | Albert Lake | 11.5 | 10.3 |
| 104 | Rivershire Pond 2 | 11.5 | 13.3 |
| 105 | Antioch Lake | 11.3 | 13.4 |
| 106 | Hook Lake | 11.3 | 13.4 |
| 107 | Briarcrest Pond | 11.2 | 12.5 |
| 108 | Lake Naomi | 11.2 | 12.5 |
| 109 | Pulaski Pond | 11.2 | 12.5 |
| 110 | Lake Napa Suwe | 11.0 | 11.0 |
| 111 | Redwing Marsh | 11.0 | 11.0 |
| 112 | West Meadow Lake | 11.0 | 11.0 |
| 113 | Lake Minear | 11.0 | 13.9 |
| 114 | Nielsen Pond | 10.7 | 12.0 |
| 115 | Lake Holloway | 10.6 | 10.6 |

Lake County average Floristic Quality Index (FQI) ranking 2000-2014.

| RANK | LAKE NAME | FQI (w/A) | FQI (native) |
|------|--|-------------|--------------|
| 116 | Sylvan Lake | 10.6 | 10.6 |
| 117 | Gages Lake | 10.2 | 12.5 |
| 118 | College Trail Lake | 10.0 | 10.0 |
| 119 | Valley Lake | 9.9 | 9.9 |
| 120 | Werhane Lake | 9.8 | 12.0 |
| 121 | Loch Lomond | 9.4 | 12.1 |
| 122 | Columbus Park Lake | 9.2 | 9.2 |
| 123 | Lake Lakeland Estates | 9.2 | 9.2 |
| 124 | Waterford Lake | 9.2 | 9.2 |
| 125 | Bluff Lake | 9.1 | 11.0 |
| 126 | Lake Fairfield | 9.0 | 10.4 |
| 127 | Lake Louise | 9.0 | 10.4 |
| 128 | Fischer Lake | 9.0 | 11.0 |
| 129 | Lake Fairview | 8.5 | 6.9 |
| 130 | Timber Lake (South) | 8.5 | 6.9 |
| 131 | East Meadow Lake | 8.5 | 8.5 |
| 132 | South Churchill Lake | 8.5 | 8.5 |
| 133 | Kemper Lake 2 | 8.5 | 9.8 |
| 134 | Lake Christa | 8.5 | 9.8 |
| 135 | Lake Farmington | 8.5 | 9.8 |
| 136 | Lucy Lake | 8.5 | 9.8 |
| 137 | Bittersweet Golf Course #13 | 8.1 | 8.1 |
| 138 | Lake Linden | 8.0 | 8.0 |
| 139 | Sand Lake | 8.0 | 10.4 |
| 140 | Countryside Lake | 7.7 | 11.5 |
| 141 | Fairfield Marsh | 7.5 | 8.7 |
| 142 | Lake Eleanor | 7.5 | 8.7 |
| 143 | Banana Pond | 7.5 | 9.2 |
| 144 | Slocum Lake | 7.1 | 5.8 |
| 145 | Lucky Lake | 7.0 | 7.0 |
| 146 | North Tower Lake | 7.0 | 7.0 |
| 147 | Lake Forest Pond | 6.9 | 8.5 |
| 148 | Ozaukee Lake | 6.7 | 8.7 |
| 149 | Leisure Lake | 6.4 | 9.0 |
| 150 | Peterson Pond | 6.0 | 8.5 |
| 151 | Little Bear Lake | 5.8 | 7.5 |
| 152 | Deer Lake Meadow Lake | 5.2 | 6.4 |
| 153 | ADID 127 | 5.0 | 5.0 |
| 154 | Island Lake | 5.0 | 5.0 |
| 155 | Liberty Lake | 5.0 | 5.0 |
| 156 | Oak Hills Lake | 5.0 | 5.0 |
| 157 | Slough Lake | 5.0 | 5.0 |
| 158 | International Mining and Chemical Lake | 5.0 | 7.1 |
| 159 | Diamond Lake | 3.7 | 5.5 |
| 160 | Lake Charles | 3.7 | 5.5 |
| 161 | Big Bear Lake | 3.5 | 5.0 |
| 162 | Sand Pond (IDNR) | 3.5 | 5.0 |
| 163 | Harvey Lake | 3.3 | 5.0 |
| 164 | Half Day Pit | 2.9 | 5.0 |
| 165 | Lochanora Lake | 2.5 | 5.0 |
| 166 | Echo Lake | 0.0 | 0.0 |
| 167 | Hidden Lake | 0.0 | 0.0 |
| 168 | St. Mary's Lake | 0.0 | 0.0 |
| 169 | Willow Lake | 0.0 | 0.0 |
| 170 | Woodland Lake | 0.0 | 0.0 |
| | Mean | 14.1 | 15.2 |
| | Median | 13.4 | 15.0 |

Aquatic Plants found at **32** sampling sites on Dunn's Lake in July 2014.
The maximum depth that plants were found was **5.1** feet.

Aquatic Plant Survey Data: Plant Species & Abundance

| Plant Density | Chara | Coontail | Duckweed | Eurasian Watermilfoil | Sago Pondweed | Southern Naiad | Watermeal | Water Stargrass | White Water Lily |
|-------------------|-------|----------|----------|-----------------------|---------------|----------------|-----------|-----------------|------------------|
| Absent | 77 | 66 | 71 | 75 | 71 | 78 | 78 | 78 | 52 |
| Present | 2 | 7 | 3 | 3 | 6 | 1 | 1 | 0 | 15 |
| Common | 0 | 4 | 5 | 1 | 1 | 0 | 0 | 1 | 6 |
| Abundant | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 3 |
| Dominant | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| % Plant Occurance | 2.5 | 16.5 | 10.1 | 5.1 | 10.1 | 1.3 | 1.3 | 1.3 | 34.2 |

Distribution of rake density across all sampling sites

| Rake Density (coverage) | # of Sites | % of Sites |
|-------------------------|------------|------------|
| No Plants | 47 | 59.5 |
| >0-10% | 16 | 20.3 |
| 10-40% | 9 | 11.4 |
| 40-60% | 2 | 2.5 |
| 60-90% | 4 | 5.1 |
| >90% | 1 | 1.3 |
| Total Sites with Plants | 32 | 40.5 |
| Total # of Sites | 79 | 100.0 |

APPENDIX B. METHODS FOR FIELD DATA COLLECTION AND LABORATORY ANALYSES

Water Sampling and Laboratory Analyses

Two water samples were collected once a month from May through September. Sample locations were at the deepest point in the lake (see sample site map), three feet below the surface, and 3 feet above the bottom. Samples were collected with a horizontal Van Dorn water sampler. Approximately three liters of water were collected for each sample for all lab analyses. After collection, all samples were placed in a cooler with ice until delivered to the Lake County Health Department lab, where they were refrigerated. Analytical methods for the parameters are listed in Table A1. Except nitrate nitrogen, all methods are from the Eighteenth Edition of Standard Methods, (eds. American Public Health Association, American Water Works Association, and Water Pollution Control Federation, 1992). Methodology for nitrate nitrogen was taken from the 14th edition of Standard Methods. Dissolved oxygen, temperature, conductivity and pH were measured at the deep hole with a Hydrolab DataSonde® 4a. Photosynthetic Active Radiation (PAR) was recorded using a LI-COR® 192 Spherical Sensor attached to the Hydrolab DataSonde® 4a. Readings were taken at the surface and then every two feet until reaching the bottom.

Plant Sampling

In order to randomly sample each lake, mapping software (ArcMap 9.3) overlaid a grid pattern onto an aerial photo of Lake County and placed points 60 or 30 meters apart, depending on lake size. Plants were sampled using a garden rake fitted with hardware cloth. The hardware cloth surrounded the rake tines and is tapered two feet up the handle. A rope was tied to the end of the handle for retrieval. At designated sampling sites, the rake was tossed into the water, and using the attached rope, was dragged across the bottom, toward the boat. After pulling the rake into the boat, plant coverage was assessed for overall abundance. Then plants were individually identified and placed in categories based on coverage. Plants that were not found on the rake but were seen in the immediate vicinity of the boat at the time of sampling were also recorded. Plants difficult to identify in the field were placed in plastic bags and identified with plant keys after returning to the office. The depth of each sampling location was measured either by a hand-held depth meter, or by pushing the rake straight down and measuring the depth along the rope or rake handle. One-foot increments were marked along the rope and rake handle to aid in depth estimation.

Wildlife Assessment

Species of wildlife were noted during visits to each lake. When possible, wildlife was identified to species by sight or sound. However, due to time constraints, collection of quantitative information was not possible. Thus, all data should be considered anecdotal. Some of the species on the list may have only been seen once, or were spotted during their migration through the area.

Table A1. Analytical methods used for water quality parameters.

| <i>Parameter</i> | <i>Method</i> |
|--|--|
| Temperature | Hydrolab DataSonde® 4a or YSI 6600 Sonde® |
| Dissolved oxygen | Hydrolab DataSonde® 4a or YSI 6600 Sonde® |
| Nitrate and Nitrite nitrogen | USEPA 353.2 rev. 2.0 EPA-600/R-93/100 Detection Limit = 0.05 mg/L |
| Ammonia nitrogen | SM 18 th ed. Electrode method, #4500 NH ₃ -F Detection Limit = 0.1 mg/L |
| Total Kjeldahl nitrogen | SM 18 th ed, 4500-N _{org} C Semi-Micro Kjeldahl, plus 4500 NH ₃ -F Detection Limit = 0.5 mg/L |
| pH | Hydrolab DataSonde® 4a, or YSI 6600 Sonde® Electrometric method |
| Total solids | SM 18 th ed, Method #2540B |
| Total suspended solids | SM 18 th ed, Method #2540D Detection Limit = 0.5 mg/L |
| Chloride | SM 18 th ed, Method #4500C1-D |
| Total volatile solids | SM 18 th ed, Method #2540E, from total solids |
| Alkalinity | SM 18 th ed, Method #2320B, potentiometric titration curve method |
| Conductivity | Hydrolab DataSonde® 4a or YSI 6600 Sonde® |
| Total phosphorus | SM 18 th ed, Methods #4500-P B 5 and #4500-P E Detection Limit = 0.01 mg/L |
| Soluble reactive phosphorus | SM 18 th ed, Methods #4500-P B 1 and #4500-P E Detection Limit = 0.005 mg/L |
| Clarity | Secchi disk |
| Color | Illinois EPA Volunteer Lake Monitoring Color Chart |
| Photosynthetic Active Radiation (PAR) | Hydrolab DataSonde® 4a or YSI 6600 Sonde®, LI-COR® 192 Spherical Sensor |

APPENDIX C. INTERPRETING YOUR LAKE'S WATER QUALITY DATA

Lakes possess a unique set of physical and chemical characteristics that will change over time. These in-lake water quality characteristics, or parameters, are used to describe and measure the quality of lakes, and they relate to one another in very distinct ways. As a result, it is virtually impossible to change any one component in or around a lake without affecting several other components, and it is important to understand how these components are linked.

The following pages will discuss the different water quality parameters measured by Lake County Health Department staff, how these parameters relate to each other, and why the measurement of each parameter is important. The median values (the middle number of the data set, where half of the numbers have greater values, and half have lesser values) of data collected from Lake County lakes from 2000-2010 will be used in the following discussion.

Temperature and Dissolved Oxygen:

Water temperature fluctuations will occur in response to changes in air temperatures, and can have dramatic impacts on several parameters in the lake. In the spring and fall, lakes tend to have uniform, well-mixed conditions throughout the water column (surface to the lake bottom). However, during the summer, deeper lakes will separate into distinct water layers. As surface water temperatures increase with increasing air temperatures, a large density difference will form between the heated surface water and colder bottom water. Once this difference is large enough, these two water layers will separate and generally will not mix again until the fall. At this time the lake is thermally stratified. The warm upper water layer is called the *epilimnion*, while the cold bottom water layer is called the *hypolimnion*. In some shallow lakes, stratification and destratification can occur several times during the summer. If this occurs the lake is described as polymictic. Thermal stratification also occurs to a lesser extent during the winter, when warmer bottom water becomes separated from ice-forming water at the surface until mixing occurs during spring ice-out.

Monthly temperature profiles were established on each lake by measuring water temperature every foot (lakes ≤ 15 feet deep) or every two feet (lakes > 15 feet deep) from the lake surface to the lake bottom. These profiles are important in understanding the distribution of chemical/biological characteristics and because increasing water temperature and the establishment of thermal stratification have a direct impact on dissolved oxygen (DO) concentrations in the water column. If a lake is shallow and easily mixed by wind, the DO concentration is usually consistent throughout the water column. However, shallow lakes are typically dominated by either plants or algae, and increasing water temperatures during the summer speeds up the rates of photosynthesis and decomposition in surface waters. Many of the plants or algae die at the end of the growing season. Their decomposition results in heavy oxygen consumption and can lead to an oxygen crash. In deeper, thermally stratified lakes, oxygen production is greatest in the top portion of the lake, where sunlight drives photosynthesis, and oxygen consumption is greatest near the bottom of a lake, where sunken organic matter accumulates and decomposes. The oxygen difference between the top and bottom water layers can be dramatic, with plenty of oxygen near the surface, but practically none near the bottom.

The oxygen profiles measured during the water quality study can illustrate if this is occurring. This is important because the absence of oxygen (anoxia) near the lake bottom can have adverse effects in eutrophic lakes resulting in the chemical release of phosphorus from lake sediment and the production of hydrogen sulfide (rotten egg smell) and other gases in the bottom waters. Low oxygen conditions in the upper water of a lake can also be problematic since all aquatic organisms need oxygen to live. Some oxygen may be present in the water, but at too low a concentration to sustain aquatic life. Oxygen is needed by all plants, virtually all algae and for many chemical reactions that are important in lake functioning. Most adult sport-fish such as largemouth bass and bluegill require at least 3 mg/L of DO in the water to survive. However, their offspring require at least 5 mg/L DO as they are more sensitive to DO stress. When DO concentrations drop below 3 mg/L, rough fish such as carp and green sunfish are favored and over time will become the dominant fish species.

External pollution in the form of oxygen-demanding organic matter (i.e., sewage, lawn clippings, soil from shoreline erosion, and agricultural runoff) or nutrients that stimulate the growth of excessive organic matter (i.e., algae and plants) can reduce average DO concentrations in the lake by increasing oxygen consumption. This can have a detrimental impact on the fish community, which may be squeezed into a very small volume of water as a result of high temperatures in the epilimnion and low DO levels in the hypolimnion.

Nutrients:

Phosphorus:

For most Lake County lakes, phosphorus is the nutrient that limits plant and algae growth. This means that any addition of phosphorus to a lake will typically result in algae blooms or high plant densities during the summer. The source of phosphorus to a lake can be external or internal (or both). External sources of phosphorus enter a lake through point (i.e., storm pipes and wastewater discharge) and non-point runoff (i.e., overland water flow). This runoff can pick up large amounts of phosphorus from agricultural fields, septic systems or impervious surfaces before it empties into the lake.

Internal sources of phosphorus originate within the lake and are typically linked to the lake sediment. In lakes with high oxygen levels (oxic), phosphorus can be released from the sediment through plants or sediment resuspension. Plants take up sediment-bound phosphorus through their roots, releasing it in small amounts to the water column throughout their life cycles, and in large amounts once they die and begin to decompose. Sediment resuspension can occur through biological or mechanical means. Bottom-feeding fish, such as common carp and black bullhead can release phosphorus by stirring up bottom sediment during feeding activities and can add phosphorus to a lake through their fecal matter. Sediment resuspension, and subsequent phosphorus release, can also occur via wind/wave action or through the use of artificial aerators, especially in shallow lakes. In lakes that thermally stratify, internal phosphorus release can occur from the sediment through chemical means. Once oxygen is depleted (anoxia) in the hypolimnion, chemical reactions occur in which phosphorus bound to iron complexes in the

sediment becomes soluble and is released into the water column. This phosphorus is trapped in the hypolimnion and is unavailable to algae until fall turnover, and can cause algae blooms once it moves into the sunlit surface water at that time. Accordingly, many of the lakes in Lake County are plagued by dense algae blooms and excessive, exotic plant coverage, which negatively affect DO levels, fish communities and water clarity.

Lakes with an average phosphorus concentration greater than 0.05 mg/L are considered nutrient rich. The median near surface total phosphorus (TP) concentration in Lake County lakes from 2000-2010 was 0.065 mg/L and ranged from a non-detectable minimum of <0.010 mg/L on seven lakes to a maximum of 3.880 mg/L on Albert Lake. The median anoxic TP concentration in Lake County lakes from 2000-2010 was 0.174 mg/L and ranged from a minimum of 0.012 mg/L in Independence Grove Lake to a maximum of 3.800 mg/L in Taylor Lake.

The analysis of phosphorus also included soluble reactive phosphorus (SRP), a dissolved form of phosphorus that is readily available for plant and algae growth. SRP is not discussed in great detail in most of the water quality reports because SRP concentrations vary throughout the season depending on how plants and algae absorb and release it. It gives an indication of how much phosphorus is available for uptake, but, because it does not take all forms of phosphorus into account, it does not indicate how much phosphorus is truly present in the water column. TP is considered a better indicator of a lake's nutrient status because its concentrations remain more stable than soluble reactive phosphorus. However, elevated SRP levels are a strong indicator of nutrient problems in a lake.

Nitrogen:

Nitrogen is also an important nutrient for plant and algae growth. Sources of nitrogen to a lake vary widely, ranging from fertilizer and animal wastes, to human waste from sewage treatment plants or failing septic systems, to groundwater, air and rainfall. As a result, it is very difficult to control or reduce nitrogen inputs to a lake. Different forms of nitrogen are present in a lake under different oxic conditions. NH_4^+ (ammonium) is released from decomposing organic material under anoxic conditions and accumulates in the hypolimnion of thermally stratified lakes. If NH_4^+ comes into contact with oxygen, it is immediately converted to NO_2^- (nitrite) which is then oxidized to NO_3^- (nitrate). Therefore, in a thermally stratified lake, levels of NH_4^+ would only be elevated in the hypolimnion and levels of NO_3^- would only be elevated in the epilimnion. Both NH_4^+ and NO_3^- can be used as a nitrogen source by aquatic plants and algae. Total Kjeldahl nitrogen (TKN) is a measure of organic nitrogen plus ammonium. Adding the concentrations of TKN and nitrate together gives an indication of the amount of total nitrogen present in the water column. If inorganic nitrogen (NO_3^- , NO_2^- , NH_4^+) concentrations exceed 0.3 mg/L in spring, sufficient nitrogen is available to support summer algae blooms. However, low nitrogen levels do not guarantee limited algae growth the way low phosphorus levels do. Nitrogen gas in the air can dissolve in lake water and blue-green algae can "fix" atmospheric nitrogen, converting it into a usable form. Since other types of algae do not have the ability to do this, nuisance blue-green algae blooms are typically associated with lakes that are nitrogen limited (i.e., have low nitrogen levels).

The ratio of TKN plus nitrate nitrogen to total phosphorus (TN:TP) can indicate whether plant/algae growth in a lake is limited by nitrogen or phosphorus. Ratios of less than 10:1 suggest a system limited by nitrogen, while lakes with ratios greater than 20:1 are limited by phosphorus. It is important to know if a lake is limited by nitrogen or phosphorus because any addition of the limiting nutrient to the lake will, likely, result in algae blooms or an increase in plant density.

Solids:

Although several forms of solids (total solids, total suspended solids, total volatile solids, total dissolved solids) were measured each month by the Lakes Management Staff, total suspended solids (TSS) and total volatile solids (TVS) have the most impact on other variables and on the lake as a whole. TSS are particles of algae or sediment suspended in the water column. High TSS concentrations can result from algae blooms, sediment resuspension, and/or the inflow of turbid water, and are typically associated with low water clarity and high phosphorus concentrations in many lakes in Lake County. Low water clarity and high phosphorus concentrations, in turn, exacerbate the high TSS problem by leading to reduced plant density (which stabilize lake sediment) and increased occurrence of algae blooms. The median TSS value in epilimnetic waters in Lake County was 8.1 mg/L, ranging from below the 0.1 mg/L detection limit to 165 mg/L in Fairfield Marsh.

TVS represents the fraction of total solids that are organic in nature, such as algae cells, tiny pieces of plant material, and/or tiny animals (zooplankton) in the water column. High TVS values indicate that a large portion of the suspended solids may be made up of algae cells. This is important in determining possible sources of phosphorus to a lake. If much of the suspended material in the water column is determined to be resuspended sediment that is releasing phosphorus, this problem would be addressed differently than if the suspended material was made up of algae cells that were releasing phosphorus. The median TVS value was 123.0 mg/L, ranging from 34.0 mg/L in Pulaski Pond to 298.0 mg/L in Fairfield Marsh.

Total dissolved solids (TDS) are the amount of dissolved substances, such as salts or minerals, remaining in water after evaporation. These dissolved solids are discussed in further detail in the *Alkalinity* and *Conductivity* sections of this document. TDS concentrations were measured in Lake County lakes prior to 2004. This practice was discontinued due to the strong correlation of TDS to conductivity and chloride concentrations. Since 2004, chloride concentrations data are collected..

Water Clarity:

Water clarity (transparency) is not a chemical property of lake water, but is often an indicator of a lake's overall water quality. It is affected by a lake's water color, which is a reflection of the amount of total suspended solids and dissolved organic chemicals. Thus, transparency is a

measure of particle concentration and is measured with a Secchi disk. Generally, the lower the clarity or Secchi depth, the poorer the water quality. A decrease in Secchi depth during the summer occurs as the result of an increase in suspended solids (algae or sediment) in the water column. Aquatic plants play an important role in the level of water clarity and can, in turn, be negatively affected by low clarity levels. Plants increase clarity by competing with algae for resources and by stabilizing sediments to prevent sediment resuspension. A lake with a healthy plant community will almost always have higher water clarity than a lake without plants. Additionally, if the plants in a lake are removed (through herbicide treatment or the stocking of grass carp), the lake will probably become dominated by algae and Secchi depth will decrease. This makes it very difficult for plants to become re-established due to the lack of available sunlight and the lake will, most likely, remain turbid. Turbidity will be accelerated if the lake is very shallow and/or common carp are present. Shallow lakes are more susceptible to sediment resuspension through wind/wave action and are more likely to experience clarity problems if plants are not present to stabilize bottom sediment.

Common Carp are prolific fish that feed on invertebrates in the sediment. Their feeding activities stir up bottom sediment and can dramatically decrease water clarity in shallow lakes. As mentioned above, lakes with low water clarity are, generally, considered to have poor water quality. This is because the causes and effects of low clarity negatively impact both plant and fish communities. Fish populations will suffer as water clarity decreases due to a lack of food and decreased ability to successfully hunt for prey. Bluegills are planktivorous fish and feed on invertebrates that inhabit aquatic plants. If low clarity results in the disappearance of plants, this food source will disappear too. Largemouth Bass and Northern Pike are piscivorous fish that feed on other fish and hunt by sight. As the water clarity decreases, these fish species find it more difficult to see and ambush prey and may decline in size as a result. This could eventually lead to an imbalance in the fish community. Phosphorus release from resuspended sediment could increase as water clarity and plant density decrease. This would then result in increased algae blooms, further reducing Secchi depth and aggravating all problems just discussed. The median Secchi depth for Lake County lakes is 2.95 feet. From 2000-2010, both Ozaukee Lake and McDonald Lake #2 had the lowest Secchi depths (0.25 feet) and West Loon Lake had the highest (23.50 feet). As an example of the difference in Secchi depth based on plant coverage, South Churchill Lake, which had no plant coverage and large numbers of Common Carp in 2003 had an average Secchi depth of 0.73 feet (over four times lower than the county average), while Deep Lake, which had a diverse plant community and few carp had an average 2003 Secchi depth of 12.48 feet (almost four times higher than the county average).

Another measure of clarity is the use of a light meter. The light meter measures the amount of light at the surface of the lake and the amount of light at each depth in the water column. The amount of attenuation and absorption (decreases) of light by the water column are major factors controlling temperature and potential photosynthesis. Light intensity at the lake surface varies seasonally and with cloud cover, and decreases with depth. The deeper into the water column light penetrates, the deeper potential plant growth. The maximum depth at which algae and plants can grow underwater is usually at the depth where the amount of light available is reduced

to 0.5%-1% of the amount of light available at the lake surface. This is called the euphotic (sunlit) zone. A general rule of thumb in Lake County is that the 1% light level is about 1 to 3 times the Secchi disk depth.

Alkalinity, Conductivity, Chloride, pH:

Alkalinity:

Alkalinity is the measurement of the amount of acid necessary to neutralize carbonate (CO_3^{2-}) and bicarbonate (HCO_3^-) ions in the water, and represents the buffering capacity of a body of water. The alkalinity of lake water depends on the types of minerals in the surrounding soils and in the bedrock. It also depends on how often the lake water comes in contact with these minerals. If a lake gets groundwater from aquifers containing limestone minerals such as calcium carbonate (CaCO_3) or dolomite (CaMgCO_3), alkalinity will be high. The median alkalinity in Lake County lakes (162 mg/L) is considered moderately hard according to the hardness classification scale of Brown, Skougstad and Fishman (1970). Because hard water (alkaline) lakes often have watersheds with fertile soils that add nutrients to the water, they usually produce more fish and aquatic plants than soft water lakes. Since the majority of Lake County lakes have a high alkalinity they are able to buffer the adverse effects of acid rain.

Conductivity and Chloride:

Conductivity is the inverse measure of the resistance of lake water to an electric flow. This means that the higher the conductivity, the more easily an electric current is able to flow through water. Since electric currents travel along ions in water, the more chemical ions or dissolved salts a body of water contains, the higher the conductivity will be. Accordingly, conductivity has been correlated to total dissolved solids and chloride ions. The amount of dissolved solids or conductivity of a lake is dependent on the lake and watershed geology, the size of the watershed flowing into the lake, the land uses within that watershed, and evaporation and bacterial activity. Many Lake County lakes have elevated conductivity levels in May, but not during any other month. This was because chloride, in the form of road salt, was washing into the lakes with spring rains, increasing conductivity. Most road salt is sodium chloride, calcium chloride, potassium chloride, magnesium chloride or ferrocyanide salts. Beginning in 2004, chloride concentrations are one of the parameters measured during the lake studies. Increased chloride concentrations may have a negative impact on aquatic organisms. Conductivity changes occur seasonally and with depth. For example, in stratified lakes the conductivity normally increases in the hypolimnion as bacterial decomposition converts organic materials to bicarbonate and carbonate ions depending on the pH of the water. These newly created ions increase the conductivity and total dissolved solids. Over the long term, conductivity is a good indicator of potential watershed or lake problems if an increasing trend is noted over a period of years. It is also important to know the conductivity of the water when fishery assessments are conducted, as electroshocking requires a high enough conductivity to properly stun the fish, but not too high as to cause injury or death.

Since 2004 measurements taken in Lake County lakes have exhibited a trend of increasing salinity measured by chloride concentrations. The median near surface chloride concentration of

Lake County Lakes was 142 mg/L. In 2009, Schreiber Lake had the lowest chloride concentration recorded at 2.7 mg/L. The maximum average chloride measurement was at 2760 mg/L at IMC. It is important to note that salt water is denser than fresh water and so it accumulates in the hypolimnion or near the bottom of the lake, this can impact mixing of bottom waters into surface waters in lakes that experience turnover. This phenomenon could have far reaching impacts to an entire ecosystem within a lake. Further, in studies conducted in Minnesota, chloride concentrations as low as 12 mg/L have been found to impact some species of algae.

pH:

pH is the measurement of hydrogen ion (H^+) activity in water. The pH of pure water is neutral at 7 and is considered acidic at levels below 7 and basic at levels above 7. Low pH levels of 4-5 are toxic to most aquatic life, while high pH levels (9-10) are not only toxic to aquatic life they may also result in the release of phosphorus from lake sediment. The presence of high plant densities can increase pH levels through photosynthesis, and lakes dominated by a large amount of plants or algae can experience large fluctuations in pH levels from day to night, depending on the rates of photosynthesis and respiration. Few, if any pH problems exist in Lake County lakes. Typically, the flooded gravel mines in the county are more acidic than the glacial lakes as they have less biological activity, but do not usually drop below pH levels of 7. The median near surface pH value of Lake County lakes was 8.37, with a minimum average of 7.07 in Bittersweet #13 Lake and a maximum of 10.40 in Summerhill Estates Lake.

Eutrophication and Trophic State Index:

The word *eutrophication* comes from a Greek word meaning “well nourished.” This also describes the process in which a lake becomes enriched with nutrients. Over time, this is a lake’s natural aging process, as it slowly fills in with eroded materials from the surrounding watershed and with decaying plants. If no human impacts disturb the watershed or the lake, natural eutrophication can take thousands of years. However, human activities on a lake or in the watershed accelerate this process by resulting in rapid soil erosion and heavy phosphorus inputs. This accelerated aging process on a lake is referred to as cultural eutrophication. The term trophic state refers to the amount of nutrient enrichment within a lake system. *Oligotrophic* lakes are usually deep and clear with low nutrient levels, little plant growth and a limited fishery. *Mesotrophic* lakes are more biologically productive than oligotrophic lakes and have moderate nutrient levels and more plant growth. A lake labeled as *eutrophic* is high in nutrients and can support high plant densities and large fish populations. Water clarity is typically poorer than oligotrophic or mesotrophic lakes and dissolved oxygen problems may be present. A *hypereutrophic* lake has excessive nutrients, resulting in nuisance plant or algae growth. These lakes are often pea-soup green, with poor water clarity. Low dissolved oxygen may also be a problem, with fish kills occurring in shallow, hypereutrophic lakes more often than less enriched lakes. As a result, rough fish (tolerant of low dissolved oxygen levels) dominate the fish community of many hypereutrophic lakes. The categorization of a lake into a certain trophic state should not be viewed as a “good to bad” categorization, as most lake residents rate their

lake based on desired usage. For example, a fisherman would consider a plant-dominated, clear lake to be desirable, while a water-skier might prefer a turbid lake devoid of plants. Most lakes in Lake County are eutrophic or hypereutrophic. This is primarily as a result of cultural eutrophication. However, due to the fertile soil in this area, many lakes (especially man-made) may have started out under eutrophic conditions and will never attain even mesotrophic conditions, regardless of any amount of money put into the management options. This is not an excuse to allow a lake to continue to deteriorate, but may serve as a reality check for lake owners attempting to create unrealistic conditions in their lakes.

The Trophic State Index (TSI) is an index which attaches a score to a lake based on its average total phosphorus concentration, its average Secchi depth (water transparency) and/or its average chlorophyll *a* concentration (which represent algae biomass). It is based on the principle that as phosphorus levels increase, chlorophyll *a* concentrations increase and Secchi depth decreases. The higher the TSI score, the more nutrient-rich a lake is, and once a score is obtained, the lake can then be designated as oligotrophic, mesotrophic or eutrophic. Table 1 (below) illustrates the Trophic State Index using phosphorus concentration and Secchi depth.

Table 1. Trophic State Index (TSI).

| Trophic State | TSI score | Total Phosphorus (mg/L) | Secchi Depth (feet) |
|----------------|----------------|-------------------------|---------------------|
| Oligotrophic | <40 | ≤ 0.012 | >13.12 |
| Mesotrophic | $\geq 40 < 50$ | $> 0.012 \leq 0.024$ | $\geq 6.56 < 13.12$ |
| Eutrophic | $\geq 50 < 70$ | $> 0.024 \leq 0.096$ | $\geq 1.64 < 6.56$ |
| Hypereutrophic | ≥ 70 | > 0.096 | < 1.64 |

Appendix D:

Chemical Fact Sheets of Common Aquatic Pesticides
from the
Wisconsin Department of Natural Resources

Diquat Chemical Fact Sheet

Formulations

Diquat, or diquat dibromide, is the common name of the chemical 6,7-dihydrodipyrido (1,2-a:2',1'-c) pyrazinediium dibromide. Originally registered by the EPA in 1986, diquat was reregistered in 1995 and is currently being reviewed again. It is sold for agricultural and household uses as well as for use on certain floating-leaf and submersed aquatic plants and some algae. The aquatic formulations are liquids: two of the more commonly used in Wisconsin are Reward™ and Weedtrine-D™ (product names are provided solely for your reference and should not be considered endorsements).

Aquatic Use and Considerations

Diquat is a fast-acting herbicide that works by disrupting cell membranes and interfering with photosynthesis. It is a non-selective herbicide and will kill a wide variety of plants on contact. It does not move throughout the plants, so will only kill parts of the plants that it contacts. Following treatment, plants will die within a week.

Diquat will not be effective in lakes or ponds with muddy water or where plants are covered with silt because it is strongly attracted to silt and clay particles in the water. Therefore, bottom sediments must not be disturbed during treatment, such as may occur with an outboard motor. Only partial treatments of ponds or bays should be conducted (1/2 to 1/3 of the water body). If the entire pond were to be treated, the decomposing vegetation may result in very low oxygen levels in the water. This can be lethal to fish and other aquatic organisms. Untreated areas can be treated 10-14 days after the first treatment.

Diquat is used to treat duckweed (*Lemna* spp.), which are tiny native plants. They are a food source for waterfowl but can grow thickly and become a nuisance. Navigation lanes through cattails (*Typha* spp.) are also

maintained with diquat. Diquat is labeled for use on the invasive Eurasian watermilfoil (*Myriophyllum spicatum*) but in practice is not frequently used to control it because other herbicide options are more selective.

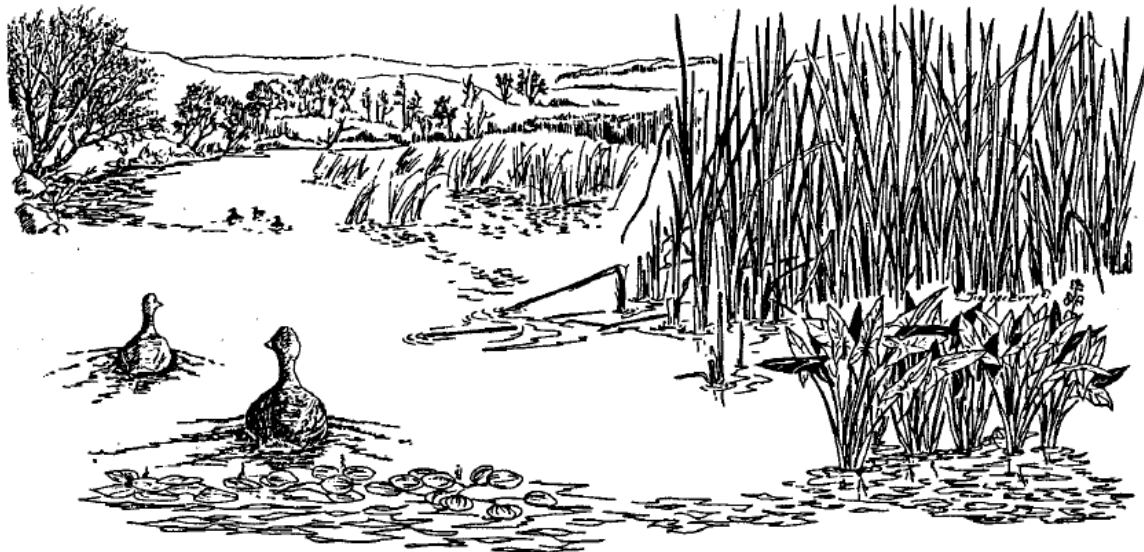
Post-Treatment Water Use Restrictions

There are no restrictions on swimming or eating fish from water bodies treated with diquat. Treated water should not be used for drinking water for one to three days, depending on the concentration used in the treatment. Do not use treated water for pet or livestock drinking water for one day following treatment. The irrigation restriction for food crops is five days, and for ornamental plants or lawn/turf, it varies from one to three days depending on the concentration used.

Herbicide Degradation, Persistence and Trace Contaminants

Diquat is not degraded by microbes. When applied to a waterbody, diquat binds with the organic matter in the sediment indefinitely. It does not degrade and will accumulate in the sediments. Diquat is usually detectable in the water column for less than a day to ~35 days after treatment. Diquat will remain in the water column longer when treating a waterbody with sandy soils due to the low organic matter and clay content. Because of its persistence and very high affinity for the soil, diquat does not leach into groundwater.

Ethylene dibromide (EDB) is a trace contaminant in diquat products. It originates from the manufacturing process. EDB is a carcinogen, and the EPA has evaluated the health risk of its presence in formulated diquat products. The maximum level of EDB in diquat dibromide is 10 ppb (parts per billion), it degrades over time, and it does not persist as an impurity.



Impacts on Fish and Other Aquatic Organisms

At application rates, diquat does not have any apparent short-term effects on most of the aquatic organisms that have been tested. However, certain species of important aquatic food chain organisms such as amphipods and *Daphnia* (water fleas) can be adversely affected at label application rates. Direct toxicity and loss of habitat are believed to be the causes. Tests on snails have shown that reproductive success may be affected, as well. These organisms only recolonize the treated area as vegetation becomes re-established.

Laboratory tests indicate walleye are the fish most sensitive to diquat, displaying toxic symptoms when confined in water treated with diquat at label application rates. Other game and panfish (e.g. northern pike, bass, and bluegills) are apparently not affected at these application rates. Limited field studies to date have not identified significant short or long-term impacts on fish and other aquatic organisms in lakes or ponds treated with diquat.

The bioconcentration factors measured for diquat in fish tissues is low. Therefore, bioconcentration is not expected to be a concern with diquat.

Human Health

The risk of acute exposure to diquat would be primarily to chemical applicators. Diquat

causes severe skin and eye irritation and is toxic or fatal if absorbed through the skin, inhaled or swallowed. Wearing skin and eye protection (e.g. rubber gloves, apron, and goggles) to minimize eye and skin irritation is required when applying diquat.

The risk to water users of serious health impacts (e.g. birth defects and cancer) is not believed to be significant according to the EPA. Some risk of allergic reactions or skin irritation is present for sensitive individuals.

For Additional Information

Environmental Protection Agency
Office of Pesticide Programs
www.epa.gov/pesticides

Wisconsin Department of Agriculture, Trade,
and Consumer Protection
<http://datcp.wi.gov/Plants/Pesticides/>

Wisconsin Department of Natural Resources
608-266-2621
<http://dnr.wi.gov/lakes/plants/>

Wisconsin Department of Health Services
<http://www.dhs.wisconsin.gov/>

National Pesticide Information Center
1-800-858-7378
<http://npic.orst.edu/>



2,4-D Chemical Fact Sheet

Formulations

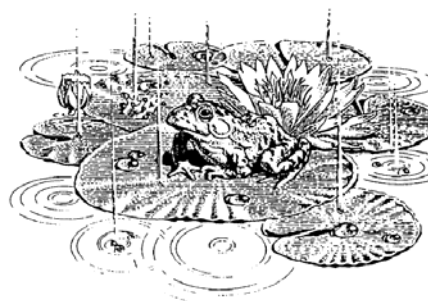
2,4-D is an herbicide that is widely used as a household weed-killer, agricultural herbicide, and aquatic herbicide. It has been in use since 1946, and was registered with the EPA in 1986 and re-reviewed in 2005. The active ingredient is 2,4-dichloro-phenoxyacetic acid. There are two types of 2,4-D used as aquatic herbicides: dimethyl amine salt and butoxyethyl ester. Both liquid and slow-release granular formulations are available. 2,4-D is sold under the trade names Aqua-Kleen, Weedar 64 and Navigate (product names are provided solely for your reference and should not be considered endorsements nor exhaustive).

Aquatic Use and Considerations

2,4-D is a widely-used herbicide that affects plant cell growth and division. It affects primarily broad-leaf plants. When the treatment occurs, the 2,4-D is absorbed into the plant and moved to the roots, stems, and leaves. Plants begin to die in a few days to a week following treatment, but can take several weeks to decompose. Treatments should be made when plants are growing.

For many years, 2,4-D has been used primarily in small-scale spot treatments. Recently, some studies have found that 2,4-D moves quickly through the water and mixes throughout the waterbody, regardless of where it is applied. Accordingly, 2,4-D has been used in Wisconsin experimentally for whole-lake treatments.

2,4-D is effective at treating the invasive Eurasian watermilfoil (*Myriophyllum spicatum*). Desirable native species that may be affected include native milfoils, coontail (*Ceratophyllum demersum*), naiads (*Najas* spp.), elodea (*Elodea canadensis*) and duckweeds (*Lemna* spp.). Lilies (*Nymphaea* spp. and *Nuphar* spp.) and bladderworts (*Utricularia* spp.) also can be affected.



Post-Treatment Water Use Restrictions

There are no restrictions on eating fish from treated water bodies, human drinking water or pet/livestock drinking water. Following the last registration review in 2005, the ester products require a 24-hour waiting period for swimming. Depending on the type of waterbody treated and the type of plant being watered, irrigation restrictions may apply for up to 30 days. Certain plants, such as tomatoes and peppers and newly seeded lawn, should not be watered with treated water until the concentration is less than 5 parts per billion (ppb).

Herbicide Degradation, Persistence and Trace Contaminants

The half-life of 2,4-D (the time it takes for half of the active ingredient to degrade) ranges from 12.9 to 40 days depending on water conditions. In anaerobic lab conditions, the half-life has been measured up to 333 days. After treatment, the 2,4-D concentration in the water is reduced primarily through microbial activity, off-site movement by water, or adsorption to small particles in silty water. It is slower to degrade in cold or acidic water, and appears to be slower to degrade in lakes that have not been treated with 2,4-D previously.

There are several degradation products from 2,4-D: 1,2,4-benzenetriol, 2,4-dichlorophenol, 2,4-dichloroanisole, chlorohydroquinone (CHQ), 4-chlorophenol and volatile organics.



Impacts on Fish and Other Aquatic Organisms

Toxicity of aquatic 2,4-D products vary depending on whether the formulation is an amine or an ester 2,4-D. The ester formulations are toxic to fish and some important invertebrates such as water fleas (*Daphnia*) and midges at application rates; the amine formulations are not toxic to fish or invertebrates at application rates. Loss of habitat following treatment may cause reductions in populations of invertebrates with either formulation, as with any herbicide treatment. These organisms only recolonize the treated areas as vegetation becomes re-established.

Available data indicate 2,4-D does not accumulate at significant levels in the bodies of fish that have been tested. Although fish that are exposed to 2,4-D will take up some of the chemical, the small amounts that accumulate are eliminated after exposure to 2,4-D ceases.

On an acute basis, 2,4-D is considered moderately to practically nontoxic to birds. 2,4-D is not toxic to amphibians at application rates; effects on reptiles are unknown. Studies have shown some endocrine disruption in amphibians at rates used in lake applications, and DNR is currently funding a study to investigate endocrine disruption in fish at application rates.

As with all chemical herbicide applications it is very important to read and follow all label instructions to prevent adverse environmental impacts.

Human Health

Adverse health effects can be produced by acute and chronic exposure to 2,4-D. Those who mix or apply 2,4-D need to protect their skin and eyes from contact with 2,4-D products to minimize irritation, and avoid inhaling the spray. In its consideration of exposure risks, the EPA believes no significant risks will occur to recreational users of water treated with 2,4-D.

Concerns have been raised about exposure to 2,4-D and elevated cancer risk. Some (but not all) epidemiological studies have found 2,4-D associated with a slight increase in risk of non-Hodgkin's lymphoma in high exposure populations (farmers and herbicide applicators). The studies show only a possible association that may be caused by other factors, and do not show that 2,4-D causes cancer. The EPA determined in 2005 that there is not sufficient evidence to classify 2,4-D as a human carcinogen.

The other chronic health concern with 2,4-D is the potential for endocrine disruption. There is some evidence that 2,4-D may have estrogenic activities, and that two of the breakdown products of 2,4-D (4-chlorophenol and 2,4-dichloroanisole) may affect male reproductive development. The extent and implications of this are not clear and it is an area of ongoing research.

For Additional Information

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Endothall Chemical Fact Sheet

Formulations

Endothall is the common name of the active ingredient endothal acid (7-oxabicyclo[2,2,1]heptane-2,3-dicarboxylic acid). Endothall products are used to control a wide range of terrestrial and aquatic plants. Both granular and liquid formulations of endothall are available for aquatic use in Wisconsin. Two types of endothall are available: dipotassium salt (such as Aquathol®) and monoamine salts (such as Hydrothol 191). Trade names are provided for your reference only and are neither exhaustive nor endorsements of one product over another.

Aquatic Use and Considerations

Endothall is a contact herbicide that prevents certain plants from making the proteins they need. Factors such as density and size of the plants present, water movement, and water temperature determine how quickly endothall works. Under favorable conditions, plants begin to weaken and die within a few days after application.

Endothall products vary somewhat in the target species they control, so it is important to always check the product label for the list of species that may be affected. Endothall products are effective on Eurasian watermilfoil (*Myriophyllum spicatum*) and also kill desirable native species such as pondweeds (*Potamogeton* spp.) and coontail (*Ceratophyllum* spp.). In addition, Hydrothol 191 formulations can also kill wild celery (*Vallisneria americana*) and some species of algae (*Chara*, *Cladophora*, *Spirogyra*, and *Pithophora*).

Endothall will kill several high value species of aquatic plants (especially *Potamogeton* spp.) in addition to nuisance species. The plants that offer important values to aquatic ecosystems often resemble, and may be growing with those plants targeted for treatment. Careful identification of plants and application of

endothall products is necessary to avoid unintended harm to valuable native species.

For effective control, endothall should be applied when plants are actively growing. Most submersed weeds are susceptible to Aquathol formulations. The choice of liquid or granular formulations depends on the size of the area requiring treatment. Granular is more suited to small areas or spot treatments, while liquid is more suitable for large areas.

If endothall is applied to a pond or enclosed bay with abundant vegetation, no more than 1/3 to 1/2 of the surface should be treated at one time because excessive decaying vegetation may deplete the oxygen content of the water and kill fish. Untreated areas should not be treated until the vegetation exposed to the initial application decomposes.

Post-Treatment Water Use Restrictions

Due to the many formulations of this chemical the post-treatment water use restrictions vary. Each product label must be followed. For all products there is a drinking water standard of 0.1 ppm and can not be applied within 600 feet of a potable water intake. Use restrictions for Hyrdtohol products have irrigation and animal water restrictions.

Herbicide Degradation, Persistence and Trace Contaminants

Endothall disperses with water movement and is broken down by microorganisms into carbon, hydrogen, and oxygen. Field studies show that low concentrations of endothall persist in water for several days to several weeks depending on environmental conditions. The half-life (the time it takes for half of the active ingredient to degrade) averages five to ten days. Complete degradation by microbial action is 30-60 days. The initial breakdown product of endothall is an amino acid, glutamic acid, which is rapidly consumed by bacteria.

Impacts on Fish and Other Aquatic Organisms

At recommended rates, the dipotassium salts (Aquathol and Aquathol K) do not have any apparent short-term effects on the fish species that have been tested. In addition, numerous studies have shown the dipotassium salts induce no significant adverse effects in aquatic invertebrates (such as snails, aquatic insects, and crayfish) when used at label application rates. However, as with other herbicide use, some plant-dwelling populations of aquatic organisms may be adversely affected by application of endothall formulations due to habitat loss.

In contrast to the low toxicity of the dipotassium salt formulations, laboratory studies have shown the monoamine salts (Hydrothol 191 formulations) are toxic to fish at dosages above 0.3 parts per million (ppm). In particular, the liquid formulation will readily kill fish present in a treatment site. By comparison, EPA approved label rates for plant control range from 0.05 to 2.5 ppm. In recognition of the extreme toxicity of the monoamine salt, product labels recommend no treatment with Hydrothol 191 where fish are an important resource.

Other aquatic organisms can also be adversely affected by Hydrothol 191 formulations depending upon the concentration used and duration of exposure. Tadpoles and freshwater scuds have demonstrated sensitivity to Hydrothol 191 at levels ranging from 0.5 to 1.8 ppm.

Findings from field and laboratory studies with bluegills suggest that bioaccumulation of dipotassium salt formulations by fish from water treated with the herbicide is unlikely. Tissue sampling has shown residue levels become undetectable a few days after treatment.



Human Health

Most concerns about adverse health effects revolve around applicator exposure. Liquid endothall formulations in concentrated form are highly toxic. Because endothall can cause eye damage and skin irritation, users should minimize exposure by wearing suitable eye and skin protection.

At this time, the EPA believes endothall poses no unacceptable risks to water users if water use restrictions are followed. EPA has determined that endothall is not a neurotoxicant or mutagen, nor is it likely to be a human carcinogen.

For Additional Information

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Fluridone Chemical Fact Sheet

Formulations

Fluridone is an aquatic herbicide that was initially registered with the EPA in 1986. The active ingredient is 1-methyl-3-phenyl-5-3-(trifluoromethyl)phenyl-4H-pyridinone. Both liquid and slow-release granular formulations are available. Fluridone is sold under the brand names Avast!, Sonar, and Whitecap (product names are provided solely for your reference and should not be considered endorsements).

Aquatic Use and Considerations

Fluridone is an herbicide that stops the plant from making a protective pigment that keeps chlorophyll from breaking down in the sun. Treated plants will turn white or pink at the growing tips after a week and will die in one to two months after treatment as it is unable to make food for itself. It is only effective if plants are growing at the time of treatment.

Fluridone is used at very low concentrations, but a very long contact time is required (45-90 days). If the fluridone is removed before the plants die, they will once again be able to produce chlorophyll and grow.

Fluridone moves rapidly through water, so it is usually applied as a whole-lake treatment to an entire waterbody or basin. There are pellet slow-release formulations that may be used as spot treatments, but the efficacy of this is undetermined. Fluridone has been applied to rivers through a drip system to maintain the concentration for the required contact time.

Plants vary in their susceptibility to fluridone, so typically some species will not be affected even though the entire waterbody is treated.

Plants have been shown to develop resistance to repeated fluridone use, so it is recommended to rotate herbicides with different modes of action when using fluridone as a control.

Fluridone is effective at treating the invasive Eurasian watermilfoil (*Myriophyllum spicatum*). It also is commonly used for control of invasive hydrilla (*Hydrilla verticillata*) and water hyacinth (*Eichhornia crassipes*), neither of which are present in Wisconsin yet. Desirable native species that are usually affected at concentrations used to treat the invasives include native milfoils, coontail (*Ceratophyllum demersum*), naiads (*Najas* spp.), elodea (*Elodea canadensis*) and duckweeds (*Lemna* spp.). Lilies (*Nymphaea* spp. and *Nuphar* spp.) and bladderworts (*Utricularia* spp.) also can be affected.

Post-Treatment Water Use Restrictions

There are no restrictions on swimming, eating fish from treated water bodies, human drinking water or pet/livestock drinking water. Depending on the type of waterbody treated and the type of plant being watered, irrigation restrictions may apply for up to 30 days. Certain plants, such as tomatoes and peppers and newly seeded lawn, should not be watered with treated water until the concentration is less than 5 parts per billion (ppb).

Herbicide Degradation, Persistence and Trace Contaminants

The half-life of fluridone (the time it takes for half of the active ingredient to degrade) ranges from 4 to 97 days depending on water conditions. After treatment, the fluridone concentration in the water is reduced through dilution due to water movement, uptake by plants, adsorption to the sediments, and break down from light and microbial action.

There are two major degradation products from fluridone: n-methyl formamide (NMF) and 3-trifluoromethyl benzoic acid. NMF has not been detected in studies of field conditions, including those at the maximum label rate.

Fluridone residues in sediments reach a maximum in one to four weeks after treatment and decline in four months to a year depending on environmental conditions. Fluridone adsorbs to clay and soils with high organic matter, especially in pellet form, and can reduce the concentration of fluridone in the water. Adsorption to the sediments is reversible; fluridone gradually dissipates back into the water where it is subject to chemical breakdown.

Impacts on Fish and Other Aquatic Organisms

Fluridone does not appear to have any apparent short-term or long-term effects on fish at application rates.

Fish exposed to water treated with fluridone absorb fluridone into their tissues. Residues of fluridone in fish decrease as the herbicide disappears from the water. The EPA has established a tolerance for fluridone residues in fish of 0.5 parts per million (ppm).

Studies on Fluridone's effects on aquatic invertebrates (i.e. midge and water flea) have shown increased mortality at label application rates.

Studies on birds indicate that fluridone would not pose an acute or chronic risk to birds. No studies have been conducted on amphibians or reptiles.

Human Health

The risk of acute exposure to fluridone would be primarily to chemical applicators. The acute toxicity risk from oral and inhalation routes is minimal. Concentrated fluridone may cause some eye or skin irritation. No personal protective equipment is required on the label to mix or apply fluridone.

Fluridone does not show evidence of causing birth defects, reproductive toxicity, or genetic mutations in mammals tested. It is not considered to be carcinogenic nor does it impair immune or endocrine function.

There is some evidence that the degradation product NMF causes birth defects. However, since NMF has only been detected in the lab and not following actual fluridone treatments, the manufacturer and EPA have indicated that fluridone use should not result in NMF

concentrations that would adversely affect the health of water users. In the re-registration assessment that is currently underway for fluridone, the EPA has requested additional studies on both NMF and 3-trifluoromethyl benzoic acid.

For Additional Information

Environmental Protection Agency
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Hamelink, J.L., D.R. Buckler, F.L. Mayer, D.U. Palawski, and H.O. Sanders. 1986. Toxicity of Fluridone to Aquatic Invertebrates and Fish. *Environmental Toxicology and Chemistry* 5:87-94.

Fluridone ecological risk assessment by the Bureau of Land Management, Reno Nevada:
http://www.blm.gov/pgdata/etc/medialib/blm/wo/Planning_and_Renewable_Resources/veis.Par.91082.File.tmp/Fluridone%20Ecological%20Risk%20Assessment.pdf



Triclopyr Chemical Fact Sheet

Formulations

Triclopyr was initially registered with the EPA in 1979 and was reregistered in 1997. Triclopyr acid has different formulations for aquatic and terrestrial use. The active ingredient triethylamine salt (3,5,6-trichloro-2-pyridinyloxyacetic acid), commonly called triclopyr, is the formulation registered for use in aquatic systems. It is sold both as a liquid (Renovate 3™) as well as a granular form (Renovate OTF™) for control of submerged, emergent and floating-leaf vegetation. There is also a liquid premixed formulation (Renovate Max G™) that contains triclopyr plus 2,4-D, another aquatic herbicide.

Aquatic Use and Considerations

Triclopyr is used to treat the invasive Eurasian watermilfoil (*Myriophyllum spicatum*). Desirable native species that may also be affected include native milfoils, water shield (*Brasenia schreberi*), pickerelweed (*Pontederia cordata*), and lilies (*Nymphaea* spp. and *Nuphar* spp.).

Triclopyr is a systemic herbicide that moves throughout the plant tissue and works by interfering with cell growth and division. Following treatment, plant growth will be abnormal and twisted, and then plants will die within two to three weeks after application. Plants will decompose over several weeks.

Triclopyr needs to be applied to plants that are actively growing. A water body should not be treated with triclopyr if there is an outlet, or in moving waters such as rivers or streams. If there is water movement at a treated site, higher concentrations or a repeated application may be required.

Post-Treatment Water Use Restrictions

There are no restrictions on swimming, eating fish from treated water bodies, or pet/livestock drinking water use. Before treated water can be used for irrigation, the concentration must be below one part per billion (ppb), or at least 120 days must pass. Treated water should not be used for drinking water until concentrations of triclopyr are less than 400 ppb.

Herbicide Degradation, Persistence and Trace Contaminants

Triclopyr is broken down rapidly by light and microbes and has a half-life (the time it takes for half of the active ingredient to degrade) of about a day. Dissipation studies in lakes indicate that the half-life in natural systems ranges from 0.5 to 7.5 days. Lakes with more organic matter in the soil will have more rapid degradation.

The initial breakdown products of triclopyr are TCP (3,5,6-trichloro-2-pyridinol) and TMP (3,5,6-trichloro-2-methoxy-pyridine). TCP and TMP appear to be slightly more toxic to aquatic organisms than triclopyr; however the peak concentration of these degradates is very low following treatment, so that they do not pose a concern to aquatic organisms. The half-lives for TCP and TMP are similar to those of triclopyr.

Triclopyr doesn't bind to soil, and limited leaching of triclopyr and its degradation products may occur. It likely is not mobile enough to contaminate groundwater, and EPA has determined that the evidence of possible leaching is not sufficient to require further study.

Impacts on Fish and Other Aquatic Organisms

Testing indicates that the aquatic formulation of triclopyr is practically non-toxic to fish and invertebrates. Species tested included catfish, trout, bluegill, minnows, crayfish and water fleas (*Daphnia* sp.). Triclopyr is slightly toxic to mallards, but at concentrations well above (400x) the highest allowed application rate. Water pH will affect toxicity because greater exposure to triclopyr will occur in low pH water. Tests have not been conducted in low pH water except for salmon species. However, the margin of safety in the toxicity tests that were conducted suggest that even in low pH water there would not be toxic effects on fish.

Tests on the degradation product TCP indicate that acute effects to bluegill and rainbow trout would not occur at label usage rates, although it is slightly more toxic than triclopyr. The degradation product TMP is moderately toxic to fish, but after treatment is found only in low proportions if it is detected at all. The EPA has requested additional data to evaluate the fate of the degradation product TCP in aquatic systems as well as its chronic toxicity to fish.

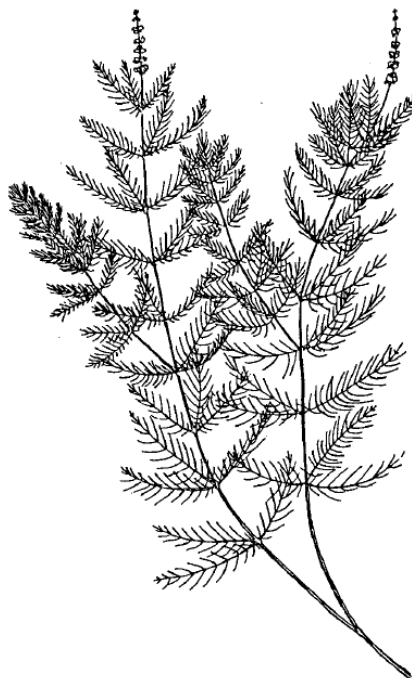
Triclopyr and TCP do not bioaccumulate and clear from fish and crayfish tissues at rates similar to that which occurs in the water. TMP does appear to bioaccumulate in fatty fish tissues, such as inedible and visceral tissues, but does not persist in fish following TMP disappearance from the water.

Human Health

The risk of acute exposure to triclopyr would be primarily to chemical applicators. Concentrated triclopyr does not pose an inhalation risk, but can cause skin irritation and eye corrosion. Persons who mix or apply triclopyr need to protect their skin and eyes from contact. In its consideration of exposure risks, the EPA believes no significant risks will occur to recreational users of water treated with triclopyr.

Triclopyr does not show evidence of birth defects, reproductive toxicity or genetic mutations in mammals tested. Triclopyr is not metabolized by humans and the majority is excreted intact. Some tumors of breast tissue

occurred in tests on rodents; however there was no consistent pattern and insufficient evidence to list triclopyr as a carcinogen. Based on its low acute toxicity to mammals, and its rapid disappearance from the water column due to light and microbial degradation, triclopyr is not considered to pose a risk to water users.



For Additional Information

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